CARE-25
Abstract Volume
March 24- 25, 2025

|| CARE-25 || CUSAT || DAS || ACARR || IMS || KSDMA || KSBB || CMFRI ||

International Conference

on

Climate Adaptation and Resilience [CARE – 25]

Bridging Science, Innovation, & Communities

March 24-25, 2025

Organized by

Department of Atmospheric Sciences (DAS) &

Advanced Centre for Atmospheric Radar Research (ACARR)

Cochin University of Science and Technology (CUSAT)

in collaboration with

Indian Meteorological Society (IMS) Cochin Chapter

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International Conference on Climate Adaptation and Resilience (CARE-25)

24-25 March, 2025, at the Seminar Complex,
Cochin University of Science and Technology (CUSAT).

CARE 25 - Program Summary

DAY 1 (24 March 2025) - Monday

Time	Program/Sessions	Venue
09:00AM -10:00AM	Conference Registration	Reception
10:00AM -11:00AM	Inaugural Session	Main Hall
11:00AM -11:30AM	Tea Break & Announcement to put up posters	Open Hall
11:30AM -01:00PM	Plenary Sessions- 2 Speakers	Main Hall
01:00PM -02:00PM	Lunch Break	Open Hall
02:00PM -03:30PM	Parallel Session 1: KSDMA-DRR	Main Hall
	Parallel Session 2: KSBB	Mini Hall-1
	Parallel Session 3: Climate Variability & Extremes (CVE)	Mini Hall-2
	Parallel Session 4: Climate Adaptation and Resilience (CAR)	Exec. Hall
03:30PM -04:00PM	Tea Break & Poster Evaluation	Open Hall
04:00PM -05:30PM	Parallel Session 1: KSDMA-DRR –Cont.	Main Hall
	Parallel Session 2: KSBB –Cont.	Mini Hall-1
	Parallel Session 3: Climate Variability & Extremes (CVE)- Cont.	Mini Hall-2
	Parallel Session 4: Tropical Weather and Climate (TWC)	Exec. Hall
06:00PM -07:30PM	Cultural Programme	Main Hall
07:30PM -09:30PM	Gala Dinner	Open Hall

DAY 2 (25 March 2025) - Tuesday

Time	Program/Sessions	Venue
09:30AM -10:30AM	Plenary Sessions- 2 Speakers	Main Hall
10:30AM -11:00AM	Tea Break & Poster Evaluation	Open Hall
11:00AM -01:00PM	Parallel Session 1: **CMFRI** – Marine Biodiversity, Ocean & Climate Change (MBC)	Main Hall
	Parallel Session 2: Climate Variability & Extremes (CVE)	Mini Hall-1
	Parallel Session 3: **Climate Change Impacts and Modeling (CCI)**	Mini Hall-2
	Parallel Session 4: Advancement in Climate Sciences (ACS)	Exec. Hall
01:00PM –02:00PM	Lunch Break	Open Hall
02:00PM -03:00PM	Panel Discussion – Theme: Weather Prediction, Climate Monitoring and Dissemination	Main Hall
03:00PM -04:00PM	Valedictory Function & Best Oral/Poster Awards	Main Hall
04:00PM -04:30PM	Tea Break	Open Hall
05:00PM -07:30PM	Alumni Meet –DAS	Main Hall
07:30PM -09:30PM	Dinner	Open Hall

*Main Hall: Anna Mani Hall, Mini Hall 1: Pisharoty Hall, Mini Hall 2: Ananthakrishnan Hall, Exe. Hall : Sikka Hall

Day-1: 24 March (Monday)

INAUGURAL SESSION (10:00– 11:00 Hrs)

PLENARY SESSION 1

24 March 2025, Time: 11.30-13.00 Hrs Venue: Hall 1 (Anna Mani Hall) Chairs: Prof. H. S. Ram Mohan, CUSAT & Dr. K. Rajendran, ICCS			
SN	**Presenting Author**	**Institute/Affiliation**	**Title**
1	**Prof. Raghu Murtugudde**	**Emeritus Professor UMD, USA & Retired Professor, IITB**	Climate Change Adaptation and Resilience - Challenges and Solutions.
2	**Prof. K Mohankumar**	**Founder Director, ACARR-CUSAT**	Celebrating Fifty Years of Meteorology at CUSAT: A Comprehensive Overview

TECHNICAL SESSION: TS-H1A (Parallel)

TS-H1A: KSDMA Joint Session - Disaster Risk Reduction (DRR) 24 March 2025, Time: 14:00-15:30 Venue: Hall 1 (Anna Mani Hall) Chairs: Dr. Sekhar Kuriakose, KSDMA & Dr. Max Martin, Christ Uinversity				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
1	Lead	Dr. Sekhar Kuriakose,	Member Secretary, KSDMA & Chief Resilience Officer, KSCCAM	Early warning dissemination systems and expectations from Academicia
2		Smt. Neetha Gopal	Scientist F & Head, IMD Trivandrum	Early Warning Systems of IMD
3	Panel Discussions on **“Role of Communities in DRR”**		**Panelists** 1. Eby Emmanuel, MRRM & Bhoomika, Poonjar 2. S. P. Ravi, President, Kerala Nadeesamrakshana Samithi 3. Vishnu Das, Director, Hume Center, Wayanad 4. Rev. Fr. Francis Kambolathuparambil, VSSS, Munnar	

TECHNICAL SESSION: TS-H2A (Parallel)

<table>
<tr><td colspan="4">TS-H2A: KSBB Side Event
Consultation On Agrobiodiversity In A Changing Climate
Guarding Custodian Farmlands for Climate Adaptation and Resilience
24 March 2025, Time: 14:00-17:30
Venue: Hall 2 (Pisharoty Hall)
Chair: Dr. R.V. Varma, Former Chairman, KSBB</td></tr>
<tr><td>1</td><td>KSBB Side Event</td><td>PANEL DISCUSSION
Topic: Climate Adaptation and Resilience of Food and Agricultural Production Landscapes of Kerala</td><td>Keynote speaker:Dr. Regine Andersen
Research Director, Biodiversity and Natural Resources, Research Professor (Dr. Polit), Fridtjof Nansen Institute, Norway</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">PANEL DISCUSSIONS</td><td colspan="2">PANEL DISCUSSION 1: On-farm Conservation of Genetic Diversity in a Changing Climate: Challenges and opportunities for both producers and consumers (Experiences of Custodian farmers).

Chair: Dr. C.K. Peethambaran, Director of Research (Retd.), KAU, Vellanikkara
Co-Chair: Dr. Easwaran E.K., Chief Forest Veterinary Officer (Retd), Kerala Forest Department
Lead Discussant: Dr. C.K. Shaju, Deputy Director (Retd), Animal Husbandry</td></tr>
<tr><td colspan="2">PANEL DISCUSSION 2: Maintaining Landscape Heterogeneity and Landrace Diversity:
Strategies for climate adaptation and resilience-building (Experiences of Custodian farmers).
Chair: Dr. K. Joseph John, Principal scientist, ICAR-NBPGR, Thrissur
Co-Chair: Dr. Vanaja T., Professor, Regional Agricultural Research Station, Pilicode, Kasaragod
Lead Discussant: Dr. Deepa, Assistant Professor, Rice Research Station, Vyttila, Ernakulam</td></tr>
<tr><td colspan="2">PANEL DISCUSSION 3: Evoking Farmers' Rights: Maximizing climate-smart and socio- economic outcomes in seed production and management (Experiences of Custodian farmers).
Chair: Dr. C. George Thomas, Former Chairman, KSBB
Co-Chair: Dr. Shakeela., Director, M S Swaminathan Research Foundation, Community Agrobiodiversity Centre, Wayanad</td></tr>
</table>

TECHNICAL SESSION: TS-H3A (Parallel)

TS-H3A: Climate Variability & Extremes (CVE) 24 March 2025, Time: 14:00-15:30 Venue: Hall 3 (Ananthakrishnan Hall) Chairs: Prof. C. A. Babu, CUSAT & Dr. Govindankutty, IIST				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
1	Lead	Dr. M. R. Ramesh Kumar	Rtd Scientist, NIO Goa	Vagaries in Monsoon: Role of Oceans
2	CARE-0049	Dr. KARTHEEK MAMIDI	DISPERSION CHARACTERSTICS OF ANISOTROPICALLY SCALED MOIST EQUATORIAL WAVES	
3	CARE-0076	DHANYA JOSEPH	RISING SST AND SEA LEVEL VARIABILITY: A GROWING RISK FOR INDIA'S WEST COAST	
4	CARE-0019	ASHISH SHAJI	CONVECTIVE CHAOS: HOW CLIMATE CHANGE ELECTRIFIES INDIAN WEST COAST?	
5	CARE-0054	PRAJWAL K	WIND-PRECIPITATION REGIMES AND MONSOON INTRASEASONAL VARIABILITY: NEW INSIGHTS FROM THE SOUTHWEST COAST OF INDIA	
6	CARE-0029	SRIPATHI GOLLAPALLI	VARIABILITY OF THE SOUTH ASIAN HIGH AND ITS IMPACT ON INDIAN SUMMER MONSOON RAINFALL: A MULTI-SCALE ANALYSIS	

TECHNICAL SESSION: TS-H4A (Parallel)

TS-H4A: KSCCAM Joint Session-Climate Adaptation and Resilience (CAR)
24 March 2025, Time: 14:00-15:30
Venue: Hall 4 (Sikka Hall)
Chairs: Dr. Krishnamohan, CUSAT & Shri. Siji. M. Thankachan, KSCCAM

SN	Talks	Presenting Author	Institute	Title
1	Lead	Dr. Deepak Gopalakrishnan (Online)	Department of Meteorology, University of reading, Reading, UK	Subtropical Jet Dynamics And Arabian Rainfall: A New Perspective
2		Dr. Vinoj V (Online)	IIT Bhubaneswar	Climate Change and the warming of the Indian Cities: Implications for Extreme Heat
2	CARE-0052	STEFY THOMAS	SOCIO-ECONOMIC VULNERABILITY AND CLIMATE RESILIENCE IN COASTAL KERALA: A MULTI-CRITERIA ASSESSMENT	
3	CARE-0095	KARTHIK	INCLUSION OF BIOETHICS IN GENERAL EDUCATION FOR CLIMATE CHANGE	
4	CARE-0103	RIYA K R	ANALYSING CLIMATE CHANGE VULNERABILITY AND ADAPTATION STRATEGIES IN KERALA	
5	CARE-0135 (ONLINE)	GOPIKRISHNAN G S	AEROSOL INHIBITION ON PHOTOCHEMICAL SURFACE OZONE FORMATION UNDER FUTURE CLIMATE AND AIR QUALITY SCENARIOS	
6	CARE-0090	LINCY DAVIS	VERIFICATION OF MEDIUM RANGE WEATHER FORECAST AND ITS ROLE IN AGROMET ADVISORY SERVICES	
7	CARE-0145 (ONLINE)	APARNNA RAVI	EXTREME EVENTS – ELUCIDATING THE DYNAMICS OF INDIAN TERRESTRIAL CARBON UPTAKE CAPACITY	

TECHNICAL SESSION: TS-H1B (Parallel)

TS-H1B: KSDMA Joint Session - Disaster Risk Reduction (DRR) 24 March 2025, Time: 16:00-17:30 Venue: Hall 1 (Anna Mani Hall) Chairs: Prof. K. Mohankumar, CUSAT & Dr. Amal Dev, CUSAT				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
1	Lead	Dr. P. S. Sunil	Professor, CUSAT	Subduction Zone Geohazards and its imprints in the Lithosphere-Atmosphere-Ionosphere coupled system
2	CARE-0067	Dr. ARAVINDH PANIKKAVEETTIL	ASSESSING VULNERABILITY AND RISK TO EXTREME WEATHER EVENTS ON THE KERALA COAST USING IPCC AR4 AND AR5 FRAMEWORKS	
3	CARE-0025	MELVIN MANOJ ABRAHAM	SOCIO-ECONOMIC VULNERABILITY AND DISASTER RESILIENCE: ASSESSING COASTAL HOUSEHOLDS IN VELIYANCODE PANCHAYAT, KERALA	
4	CARE-0032	GAYATHRI R	COASTAL DISASTER RISK REDUCTION AND COMMUNITY RESILIENCE: A CASE STUDY FROM THALIKKULAM PANCHAYAT	
5	CARE-0026	MIKHA KHOSH T L	ASSESSING COASTAL VULNERABILITY AND ENHANCING DISASTER RESILIENCE: A SOCIOECONOMIC STUDY IN ERIYAD GRAMA PANCHAYAT, KERALA	
6	CARE-0020	ANJITHA A C	FIGHTING CLIMATE UNCERTAINTY: VULNERABILITY AND RESILIENCE IN KERALA'S COFFEE FARMING	
7	CARE-0035	HEMAVARSHINI B R	AGRICULTURAL DROUGHT VULNERABILITY ASSESSMENT FOR ODDANCHATRAM TALUK, TAMIL NADU FOR THE YEARS 2000, 2008, 2016 AND 2022 USING GEOSPATIAL TECHNIQUES	

TECHNICAL SESSION: TS-H3B (Parallel)

TS-H3B: Climate Variability & Extremes (CVE) (Cont.)
24 March 2025, Time: 16:00-17:30
Venue: Hall 3 (Ananthakrishnan Hall)
Chairs: Prof. K. Satheeshan, CUSAT & Shri. Baby Chakrapani, CUSAT

SN	Talks	Presenting Author	Institute	Title
1	Lead	Dr. Govindan Kutty, IIST, TVM	Professor, IIST	From Dynamics to Predictability: Leveraging Ensembles for Improved Weather Forecasts
2	CARE-0036	AMITA PRABHU		INFLUENCE OF SOUTHERN ANNULAR MODE EXTREMES ON SUMMER MONSOON RAINFALL IN INDIA AND WEST AFRICA
3	CARE-0042	TESNA MARIA		MOISTURE TRANSPORT AND ITS LINK WITH EXTREME MONSOON RAINFALL OVER THE WEST COAST OF INDIA
4	CARE-0045	ANCY P		DIURNAL AND SPATIAL VARIABILITY OF MONSOON RAINFALL OVER THE WEST COAST OF INDIA: INFLUENCE OF ATMOSPHERIC DYNAMICS AND MOISTURE TRANSPORT
5	CARE-0132	ARUN V		FEATURES OF RAINFALL DISTRIBUTION DURING TRANSITION FROM SOUTH WEST MONSOON TO POST MONSOON
6	CARE-0107	BICHU B		INCREASING INTENSITY OF POTENTIAL MESO TO SYNOPTIC SCALE LOW PRESSURE SYSTEMS IN THE NORTH INDIAN OCEAN: NEED OF AN EFFECTIVE EARLY WARNING SYSTEM FOR SOUTH-WEST COAST OF INDIA.
7	CARE-0083	ADARSH T		CLIMATE VARIABILITY AND ITS IMPACT ON PUBLIC HEALTH: A BIBLIOMETRIC STUDY
8	CARE-0031	LAKSHMAN KESIREDDY		HIGH-RESOLUTION ANALYSIS OF SEVERE HEAT WAVE DYNAMICS AND THERMAL DISCOMFORT ACROSS INDIA
9	CARE-0116	ATHIRA SALEEVAN		IMPACT OF FOREST FIRE ON SOIL SYSTEMS IN SOUTHERN WESTERN GHATS, KERALA

TECHNICAL SESSION: TS-H4B (Parallel)

TS-H4B: Tropical Weather and Climate (TWC) 24 March 2025, Time: 16:00-17:30 Venue: Hall 4 (Sikka Hall) Chairs: Dr. Manoj M G., CUSAT & Dr. Abish B., KUFOS				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
1	Lead	Dr. Jayasankar C. B. (Online)	Florida Sate University, USA	Diurnal Temperature Range Projections for India: A regional climate modeling approach
2		Dr. Baiju Dayanandan (Online)	University of Nizwa, Oman	Decadal Temperature Changes in Oman (1981–2020): A Spatiotemporal Assessment
2	CARE-0014 (Online)	SEETHA CJ	EXCHANGE BETWEEN ATMOSPHERIC BOUNDARY LAYER AND FREE TROPOSPHERE OVER THE INDIAN MONSOON REGION	
3	CARE-0108	ARDRA T S	EXPOSURE TO SURFACE OZONE AND ITS ASSOCIATED HEALTH EFFECTS IN INDIA FOR THE YEAR 2022	
4	CARE-0027	AJITH P P	PRE-MONSOON RAINFALL VARIABILITY OVER INDIA IN ASSOCIATION WITH MJO AND ENSO	
5	CARE-0129	KRISHNA KUMAR E.K	CONTRASTING REGIONAL RESPONSES OF INDIAN SUMMER MONSOON RAINFALL TO EXHAUSTED SPRING AND CONCURRENTLY EMERGING SUMMER EL NIÑO EVENTS	

Day-2: 25 March (Tuesday)

PLENARY SESSION 2

25 March 2025, Time: 09.30-10.30 Hrs
Venue: Hall 1 (Anna Mani Hall)
Chairs: Prof. Mohammad Hatha, CUSAT & Prof. P. Mohanan, CUSAT

SN	Presenting Author	Institute/Affiliation	Title
1	**Prof. Raghu Murtugudde**	**Emeritus Professor UMD, USA & Retired Professor, IITB**	Ocean Ecosystems - Silent Sufferers or Active Amplifiers?
2	**Dr. Swapna Panickal**	**Scientist F, Dy.Director, CCCR, IITM, Pune**	Coupled Modeling System for Assessing Regional Climate Response to Global Climate Change

TECHNICAL SESSION: TS-H1C (Parallel)

TS-H1C: CMFRI Joint Sessions on Marine Biodiversity, Oceans & Climate Change (MBC)
25 March 2025, Time: 11:00-13:00
Venue: Hall 1 (Anna Mani Hall)
Chairs: Dr. Saji P. K., CUSAT & Dr. Imelda Joseph, Principal Scientist, CMFRI.

SN	Talks	Presenting Author	Institute	Title
1	Lead	Dr. Ratheesh,	Scientist, CMFRI	Impacts of climate change on marine biodiversity and fisheries.
2		Dr. Vinu Valsala	Scientist F & Head, DESK, IITM	Climate Variability and Predictability of small Pelagic Fishes of Indian Coasts from a dynamic Modeling perspective.
3	CARE-0037	ASWANI S	DROUGHT MANAGEMENT IN RICE USING FOLIAR APPLICANTS	
4	CARE-0089	VENKADESH SAMYKANNU	SPATIO-TEMPORAL ASSESSMENT OF ECOLOGICAL VARIABILITY IN PUNJAB USING REMOTE SENSING ECOLOGICAL INDEX AND PADDY YIELD ANALYSIS	
5	CARE-0030	MALAVIKA A R	COMPARATIVE ANALYSIS AND STATISTICAL EVIDENCE OF DEEP OCEAN WARMING TREND IN THE ARABIAN SEA AND BAY OF BENGAL	
6	CARE-0117	AVINASH PAUL	A CASE STUDY OF THE LONGEST-LASTING MARINE HEATWAVE IN THE SOUTHEAST ARABIAN SEA	
7	CARE-0119	URMILA P	CLIMATE CHANGE AND RISING UNDERWATER NOISE LEVEL IN THE INDIAN OCEAN: IMPLICATIONS ON ACOUSTIC COMMUNICATION AND SENSING	
8	CARE-0121	PEARL JO AN K	CLIMATE VARIATION EFFECTS ON SOUND PROPAGATION LOSS IN SOUTH EASTERN ARABIAN SEA	
9	CARE-0013	HARIKRISHNAN NAMBOOTHIRY N	AN ANALYSIS OF URBAN HEAT ISLAND PHENOMENA IN THE URBAN AGGLOMERATIONS OF ERNAKULAM AND THIRUVANANTHAPURAM DISTRICTS OF KERALA	
10	CARE-0064	MEGHA MARIA LAL	BUILDING CLIMATE RESILIENT CITIES; THE ROLE OF ECO INNOVATION AND SUSTAINABLE INFRASTRUCTURE	

TECHNICAL SESSION: TS-H2C (Parallel)

TS-H2C: Climate Variability and Extremes (CVE) (Cont.)
25 March 2025, Time: 11:00-13:00
Venue: Hall 2 (Pisharoty Hall)
Chairs: Dr. Sabin. T. P, IITM & Dr. M. R. Ramesh Kumar, NIO, Goa

SN	Talks	Presenting Author	Institute	Title
1	Lead	Prof. Jayanarayan Kuttipurathu	IIT Kharagpur	Air pollution in India in a climate change context: impact of policies and environmental regulations
2		Prof. Girish Gopinath	KUFOS	Geospatial Technology for Mapping, Monitoring and Modelling of Landslides
3	CARE-0066	NANDHULAL K	INVESTIGATION ON THERMODYNAMIC PARAMETERS ASSOCIATED WITH THUNDERSTORM ACTIVITY IN KERALA, INDIA	
4	CARE-0065	AMINA HANEEF	MINI CLOUDBURST AND KOOTTICKAL LANDSLIDE: A HYDROMETEOROLOGICAL PERSPECTIVE ON EXTREME WEATHER EVENTS	
5	CARE-0120	ANU UNNY	A CRITICAL ANALYSIS OF SELECTED STATE ACTION PLANS ON CLIMATE CHANGE IN INDIA	
6	CARE-0113	JISHA K VISHAL	IMPACT OF VOLCANIC AEROSOLS ON THE INDIAN SUMMER MONSOON: INSIGHTS FROM THE PAST MILLENIUM	
7	CARE-0015	DR. SREEKUMAR HARIDAS	LOOMING DROUGHT ON INDIA'S WEST COAST: INSIGHTS FROM CMIP6 PROJECTIONS	
8	CARE-0085	SALMA JOSE	COMPREHENSIVE MONITORING AND ANALYSIS OF AEROSOL OPTICAL PROPERTIES IN THE CALICUT REGION USING ADVANCED OPTICAL INSTRUMENTS	
9	CARE-0096	BREANILA PAUL A	MARINE HEATWAVES IN THE ARABIAN SEA: EL NIÑO'S INFLUENCE AND MONSOON SEASON DYNAMICS	

TECHNICAL SESSION: TS-H3C (Parallel)

TS-H3C: Climate Change Impacts and Modeling (CCI) 25 March 2025, Time: 11:00-13:00 Venue: Hall 3 (Ananthakrishnan Hall) Chairs: Dr. Madhu V., CUSAT & Dr. Vinod Shankar, Indian Air Force				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
1	Lead	Dr. Praveen V. K	Scientist, IITM	Advancing the IITM Earth System Model: Insights in Version 3 Development
2		Dr. Hamza Varikoden	Scientist, IITM	Recent changes in the rainfall pattern over Western Ghats during southwest monsoon period
3		Prof. Sandeep, S	IIT, Delhi	Weakening of Indian Summer Monsoon in Response to Polar Sea Ice Melt
4	Invited	Prof. Sanjay Kumar Mehta	SRM	Overview On The Studies Of Atmospheric Boundary Layer Over The Indian Monsoon Region
5	CARE-0023	BALASUNDHAR B V	COMPREHENSIVE EVALUATION OF AEOLUS WIND PRODUCTS AGAINST IN-SITU OBSERVATIONS AND RE-ANALYSIS DATASETS OVER THE INDIAN MONSOON REGION	
6	CARE-0084	VINOD P G	GEO-SPATIAL ANALYSIS OF EROSION AND DEPOSITION TRENDS IN THE CHALIYAR RIVER BASIN, KERALA (2014–2024) USING REMOTE SENSING AND GIS-BASED SPECTRAL INDICES	

TECHNICAL SESSION: TS-H4C (Parallel)

TS-H4C: Advancement in Climate Sciences (ACS)
25 March 2025, Time: 11:00-13:00
Venue: Hall 4 (Sikka Hall)
Chairs: Dr. Sreekala P P, CUSAT & Dr. Ajil Kottayil, CUSAT

SN	Talks	Presenting Author	Institute	Title
1	Lead	Dr. SHINTO ROOSE (online)	McGill University, CANADA	APPLICATION OF HIGH-RESOLUTION CLIMATE SIMULATIONS TO UNDERSTAND THE IMPACT OF URBAN HEAT MITIGATION STRATEGIES IN MONTREAL
2		Dr. ATHIRA U N (Online)	KAUST	CHARACTERISTICS OF WEATHER EXTREMES OVER ARABIAN PENINSULA
3	CARE-0069	Dr. KAVYA JOHNY	WHEN AI MEETS METEOROLOGY: MODELLING THE 2018 EXTREME KERALA FLOOD	
4	CARE-0041	KRISHNA JAYAMOHAN	DEEP LEARNING-BASED PREDICTION MODEL AND EARLY WARNING FOR RAINFALL-INDUCED LANDSLIDES IN IDUKKI, KERALA	
5	CARE-0040	ELIZABETH SHANI N X	OFFSHORE WINDFARMS AND UNDERWATER NOISE PROLIFERATION	
6	CARE-0168	SARATH KUMAR D	URBAN SPRAWL ASSESSMENT USING AI BASEDML TECHNIQUES - A CASE STUDY ON COIMBATORE CITY, TAMILNADU	
7	CARE-0131 (Online)	MEHZOOZ NIZAR	CLOUDSENSE: A MODEL FOR CLOUD TYPE IDENTIFICATION USING MACHINE LEARNING FROM RADAR DATA	

TECHNICAL SESSION: TS-H1D

TS-H1D: Weather Prediction, Climate Monitoring and Dissemination 25 March 2025, Time: 14:00-15:30 Venue: Hall 1 (Anna Mani Hall) Chairs: Dr. P. V. Revikumar, Qatar Aeronautical Academy & Smt. Sudha Namboothiri (Times of India)				
SN	**Talks**	**Presenting Author**	**Institute**	**Title**
Panel Discussions on **"Weather Prediction, Climate Monitoring and Dissemination"**			**Panelists** Dr. Max Martin, Christ University : **Forecasting with Fishers: A Community-based Approach to Climate Adaptation.** Dr. Susmitha, IITM : **Extended Range Prediction and Applications.** Dr. Prasanth Pillai, IITM : **Seasonal Prediction of Rainfall and Temperature over Indian region.** Dr. Sabin T P: **The Need for High-Resolution Climate Simulations for Sectoral Applications.** Mr. K. Jamshad (Senior Sub Editor, Suprabhatham Daily: **Role of Media in the Dissemination of Weather forecasts.**	

15:30 PM – 16:00 PM Valedictory Function and Best Oral/Poster Awards
16:00 PM – 16:30 PM Tea Break
17:00 PM - 17:30 PM Alumni Meet (Venue: Main Hall)
19:30 PM - 21:30 PM Dinner

Poster Evaluation (24 March, 03:30 PM- 04:00 PM) Theme:

Climate Variability and Extreme Weather Events - 17

CARE-0028	KARTHIKA G	STRENGTHENING TRADE WINDS IN A CHANGING CLIMATE
CARE-0033	NEETHU C S	INTENSIFICATION OF HEAT WAVES IN INDIA: SYNOPTIC CONDITIONS AND ATMOSPHERIC DYNAMICS
CARE-0044	SREESHMA K	INTRA SEASONAL RAIN ISOTOPIC DYNAMICS OF BAY OF BENGAL REGION
CARE-0053	NIRANJANA KRISHNA	ANALYZING THE HEAT WAVE AND ITS IMPACT ON HEAT STRESS: A COMPARATIVE STUDY BETWEEN RAJASTHAN AND ANDHRA PRADESH
CARE-0068	ARUN P THOMAS	SEASONAL VARIABILITY OF PM2.5 AND PM10 IN KOCHI, INDIA; INFLUENCE OF COVID-19 LOCKDOWNS AND EXTREME POLLUTION EVENTS ON AIR QUALITY
CARE-0071	SHARON WILLIAMS	BOUNDARY LAYER AND CLOUD CHARACTERISTICS OBSERVED BY CEILOMETER AT A TROPICAL STATION DURING THE 2024 SOUTHWEST MONSOON
CARE-0072	RISNA USMAN A	RAPID INTENSIFICATION OF TROPICAL CYCLONE OVER NORTH INDIAN OCEAN
CARE-0075	FATHIMA KAMARUDHEEN	EVALUATION OF TREND ANALYSIS METHODS USING IMD DATASET (1901 TO 2023) OVER INDIA
CARE-0078	RONA MARIA SUNIL	STJ-MODULATED TEJ VARIABILITY: A NEW PERSPECTIVE ON INTRASEASONAL MONSOON DYNAMICS
CARE-0081	THANAYA PRADEEP	ENSO MODULATION OF ABSORBING AEROSOL DYNAMICS OVER THE INDO-GANGETIC PLAIN UNDER A CHANGING CLIMATE.
CARE-0082	BETSY KB	ROLE OF AEROSOLS ON PROLONGED EXTREME HEATWAVE

		EVENT OVER INDIA AND ITS IMPLICATION TO ATMOSPHERIC BOUNDARY LAYER
CARE-0091	SREEVIDYA RAVI	ANALYSIS OF THE EXTREME RAINFALL EVENT OVER KERALA ON OCTOBER 16, 2021, USING NUMERICAL SIMULATION: A CASE STUDY
CARE-0099	NAVEEN A Y	DECODING LANDSLIDE RISKS: A UNIFIED AHP, GIS, AND RAINFALL THRESHOLD APPROACH IN IDUKKI DISTRICT, KERALA
CARE-0106	AKSHAYA MURALEEDHARAN V	CHARACTERISTICS OF INTERNAL WAVES ASSOCIATED WITH EL-NINO YEARS IN THE NORTHERN BAY OF BENGAL USING OMNI BUOY DATA - BD08
CARE-0109	HINDHIYA SHABU	MULTIDECADAL VARIABILITY IN ENSO-INDIAN MONSOON COUPLING IN LAST MILLENNIUM COUPLED MODEL SIMULATIONS AND PALEOCLIMATE DATA ASSIMILATION PRODUCTS
CARE-0112	SUHA A SALIM	ASSESSING HEAT STRESS TRENDS IN KERALA: A REGIONAL ANALYSIS USING HEAT INDEX
CARE-0114	P N MUHAMMED ALTHAF	CHANGING PATTERNS OF MONSOONAL RAINFALL AND CLIMATE VARIABILITY OVER NORTHWEST INDIA: A CENTURY-LONG PERSPECTIVE ON RAINFALL TRENDS, EXTREMES, AND CIRCULATION DYNAMICS

Poster Evaluation (25 March 2025, 10:30 AM- 11:00 AM)

Disaster Risk Reduction and Early Warning Systems – 3

CARE-0073	VISHNU SUBRAN	LANDSLIDE SUSCEPTIBILITY ASSESSMENT USING FREQUENCY RATIO METHOD IN SUB-WATERSHEDS OF MEENACHIL RIVER BASIN
CARE-0093	SREELAKSHMI K S	EXPLORING THE MADDEN-JULIAN OSCILLATION'S INFLUENCE ON KERALA'S RAINFALL DYNAMICS
CARE-0155	SURAJ P R	SITE SPECIFIC SLOPE STABILITY ANALYSIS USING LIMIT EQUILIBRIUM METHOD (LEM) FOR SELECTED LANDSLIDE SUSCEPTIBLE SOIL SLOPE FACES OF MALAPPURAM DISTRICT OF KERALA, INDIA

Sustainable Infrastructure and Urban Resilience - 3

CARE-0092	SRIYANSU NAYAK	SPATIOTEMPORAL ANALYSIS OF LAND USE LAND COVER CHANGES ON URBAN HEAT ISLAND INTENSIFICATION AND THERMAL COMFORT IN PALAKKAD, KERALA
CARE-0111	HARINANDANA M S	URBAN HEAT ISLAND: A CLIMATOLOGICAL PERSPECTIVE
CARE-0059	ABHILASH U BAGUNAVAR	INFLUENCE OF SOIL TEMPERATURE ON SOYBEAN ECOSYSTEM

AI/ML Techniques in Climate Sciences - 3

CARE-0034	DHARMADAS JASH	PREDICTING THUNDERSTORM EVOLUTION USING DEEP LEARNING MODELS WITH DOPPLER WEATHER RADAR OBSERVATIONS.
CARE-0097	AJAYKUMAR V C	OPTIMIZING RAINFALL PREDICTION WITH DEEP LEARNING ALGORITHMS AND ENSEMBLE METHODS
CARE-0098	ABHIJITH PRASAD M	APPLICATIONS OF AI IN SEA SURFACE TEMPERATURE MODELLING: A REVIEW

Advancement in Observational Techniques – 5

CARE-0009	ANGEL ANITA CHRISTY	A CUTTING-EDGE WIND PROFILING RADAR FOR EXPLORING THE ATMOSPHERIC BOUNDARY LAYER
CARE-0024	ATHIRA BABY	STUDIES ON ENHANCED LIGHTNING ACTIVITY OVER THE LIGHTNING HOTSPOT OF INDIA
CARE-0084	VINOD P G	INTEGRATING REMOTE SENSING AND STATISTICAL MODELLING FOR WATER QUALITY ASSESSMENT USING SENTINEL-2: A CASE STUDY OF SASTHAMKOTTA LAKE, KERALA
CARE-0085	SALMA JOSE	INVESTIGATION OF ATMOSPHERIC NO, NO2, OZONE, AND NITRATE RADICAL FLUCTUATIONS IN CALICUT USING CAVITY-ENHANCED MEASUREMENTS
CARE-0115	Dr AISWARYA S	WAVELENGTH-RESOLVED OPTICAL PROPERTIES RETRIEVAL OF AMBIENT AEROSOLS USING A NOVEL CAVITY-ENHANCED ALBEDOMETER

Climate Modeling and Forecasting - 3

CARE-0100	CHANDANA B JYOTHI	MODELING THE FUTURE OF RICE CULTIVATION IN CENTRAL KERALA: CLIMATE CHANGE AND YIELD PROJECTIONS
CARE-0125	PRAVEEN S	HARNESSING WIND ENERGY DURING THE MONSOON SEASON: OPPORTUNITIES AND CHALLENGES FOR INDIA
CARE-0144	PRASANTH A. PILLAI	EFFICIENCY OF CLIMATE FORECAST SYSTEM CFSV2 TO PREDICT THE REGIONAL SCALE DROUGHT EVENTS OVER INDIA

Application of AI in Sea Surface Temperature Modelling: A Review

Abhijith Prasad M.[1,*], Nimmi R. Nair[1], T. A. Ferose Babu
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ABSTRACT

Sea Surface Temperature (SST) is a pivotal factor in the Earth's climate system, influencing atmospheric circulation, ocean currents, and the occurrence of extreme weather events. Accurate modelling of SST is essential for understanding climate variability, predicting weather anomalies, and assessing the impacts of climate change. Traditional modelling approaches, including physics-based models and statistical techniques, often face challenges in capturing the complex, nonlinear interactions that govern SST variations. In recent years, the techniques of Deep Learning (DL) has emerged as a transformative tool in climate science, offering advanced capabilities to model intricate patterns and relationships within extensive datasets. For instance, a deep learning model was developed to forecast global monthly mean SST anomalies using more than 70 years of data, demonstrating significant potential in long-range predictions of SST anomalies.

To address the challenges of cloud cover in satellite imagery, DL techniques have been employed to reconstruct SST data, enhancing the completeness and reliability of datasets for environmental assessments and climate research. Graph-based deep learning approaches have also been explored for SST forecasting, leveraging the spatial properties of climate data to improve prediction accuracy. A study demonstrated that Graph Neural Networks (GNNs) could outperform traditional models in one month-ahead SST predictions across various ocean regions. Furthermore, integrated DL approaches have been developed to forecast Marine Heatwaves (MHWs), combining graph representation, imbalanced regression, and temporal diffusion techniques. This methodology has shown improved prediction capabilities for MHWs up to six months in advance, highlighting the potential of DL in enhancing climate forecasting methodologies. The application of deep learning in SST modelling is a significant advancement in climate sciences, providing more accurate and efficient forecasting tools. The continued integration of deep learning with climate modelling frameworks will be pivotal in addressing the pressing challenges posed by climate change, ensuring more reliable predictions of future oceanic and atmospheric conditions.

Keywords: Deep Learning, Sea Surface Temperature, Climate Change.

Abhilash U. Bagunavar
CARE - 0059

Influence of Soil Temperature on Soybean (Glycine Max) Ecosystem

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[2]Department of Agriculture Meteorology, UAS, Dharwad, Karnataka - 580 005.

[*]Presenting Author: Abhilash B.

ABSTRACT

A field experiment was conducted at the University of Agricultural Sciences (UAS), Dharwad, Karnataka, to evaluate the influence of soil temperature on soybean (Glycine max) growth and productivity. The study analyzed soil temperature variations and their impact on seedling emergence, root nodulation, nutrient availability, and overall crop performance under different environmental and management conditions. Results indicated that warmer soil temperatures enhanced microbial activity and nitrogen fixation by symbiotic rhizobia, leading to improved plant growth. However, excessively high temperatures reduced soil moisture retention and affected nutrient uptake efficiency. Furthermore, soil temperature fluctuations due to climate change were found to alter phenological stages, pest dynamics, and weed competition.

Higher soil temperatures accelerated soybean development but reduced grain-filling duration, potentially affecting yield, while lower temperatures delayed plant maturity, impacting overall productivity. These variations highlight the need for adaptive management strategies such as conservation tillage, mulching, and optimal irrigation practices to regulate soil temperature and mitigate adverse effects. Understanding the influence of soil temperature on the soybean ecosystem is crucial for improving crop management practices and ensuring sustainable production. The findings from this study at UAS, Dharwad, provide valuable insights into optimizing soil temperature conditions for maximizing soybean productivity in semi-arid tropical regions. Future research should focus on developing climate-resilient soybean varieties and refining agronomic techniques to mitigate temperature-induced stress, ensuring stable yields despite environmental fluctuations.

Keywords: Soil Temperature, Soybean Growth, Microbial Activity, Nutrient Availability, Climate Change, Crop Management.

Climate Variability and its impact on Public Health: A Bibliometric Study

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ABSTRACT

Climate variability profoundly impacts public health, shaping disease patterns, mortality rates, and healthcare systems. This study conducts a bibliometric analysis on research exploring the relationship between climate variability and public health from 2000 to 2024. Using data from Web of Science and PubMed, a total of 4,812 documents were analysed through Rstudio to identify key research trends, influential publications, leading authors, and thematic developments. Bibliometric techniques such as citation analysis, authorship analysis, keyword co-occurrence mapping, and thematic evolution and analysis were employed to uncover the intellectual structure of this research domain.

Findings reveal a surge in climate-health research, especially in the past five years, with strong interdisciplinary collaborations in environmental science, epidemiology, and policy. While publication volume was relatively low in the early 2010s, it laid the foundation for the exponential growth observed in later years. Citation analysis identified the most influential studies and journals, while countries production highlighted contribution of countries over period of time. Keyword analysis revealed evolving research themes, emphasizing adaptation strategies, resilience-building, and policy integration. Authorship and affiliation production over time showcased the global nature of climate-health research, with increasing contributions from diverse disciplines and geographic regions. This study provides a roadmap for future research, emphasizing the need for evidence-based strategies to combat climate-driven health risks.

Keywords: Climate Variability, Public Health, Bibliometric Analysis, Research Trend, Climate Change.

Wavelength-resolved Optical Properties Retrieval of Ambient Aerosols Using a Novel Cavity-Enhanced Albedometer

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[*]Presenting Author: Nithyaja B.

ABSTRACT

Aerosols play a crucial role in atmospheric radiative forcing, yet their optical properties remain challenging to quantify accurately. We present a wavelength resolved cavity-enhanced albedometer designed for high-sensitivity retrieval of extinction, scattering, and absorption coefficients of atmospheric aerosols. The system employs high-reflectivity cavity mirrors to enhance the optical path length, coupled with CCD spectrometers for spectrally resolved measurements in the 529–537 nm range. Field measurements were conducted at NIT Calicut, capturing diurnal variations in aerosol optical properties.

The absorption coefficients obtained were validated against an aethalometer, demonstrating strong agreement. Additionally, Ångström exponents and complex refractive indices were retrieved using a Mie-scattering- based inverse algorithm (PyMieScatt), revealing the presence of absorbing aerosols. The integration of high-reflectivity mirrors within the nephelometer effectively minimized truncation errors, enhancing measurement accuracy. These results establish the cavity-enhanced albedometer as a robust tool for aerosol characterization with applications in air quality monitoring and climate research.

Keywords: Cavity-enhanced Albedometer, Aerosol Optical Properties, Extinction, Scattering, Absorption, Single Scattering Albedo, Complex Refractive Index.

Ajaykumar V. C.
CARE - 0097

Optimizing Rainfall Prediction With Deep Learning Algorithms and Ensemble Methods

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ABSTRACT

Accurate rainfall prediction is crucial for effective agricultural planning, water resource management and disaster preparedness. This study investigates the performance of various deep learning algorithms in predicting rainfall in Kerala using historical meteorological data from the past 40 years. Three distinct models: Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), and Long Short-Term Memory (LSTM) networks, in predicting rainfall based on meteorological parameters such as maximum and minimum temperature, forenoon and afternoon relative humidity, windspeed, and previous rainfall data. Additionally, we explore the effectiveness of an ensemble model, combining predictions from all three individual models, to improve the accuracy of rainfall prediction. Data preprocessing involved feature engineering, including the creation of lagged rainfall variables and rolling averages of temperature and humidity.

The dataset was split into training and testing sets, and features were standardized for model input. Each model was trained and evaluated using root mean squared error (RMSE) and R^2 as performance metrics. The LSTM model, ANN, and CNN were evaluated individually, and the results were compared to the ensemble model, which averaged the predictions of the three models. The results indicated that the performance of the LSTM, ANN, and CNN models was comparable, and the ensemble model performed slightly better than the individual models, showing a modest improvement in prediction accuracy. Additionally, models were applied to other districts, where the predicted and actual rainfall were in good agreement, further validating the generalizability of the approach. These findings suggest that while deep learning models can offer reasonable predictions for rainfall forecasting, further improvements could be achieved by optimizing the models or Incorporating additional features. This study also highlights the potential of ensemble methods to enhance predictive performance in meteorological forecasting tasks.

Keywords: Rainfall, Ensemble Model, ANN, CNN, LSTM.

Ajith P. P.
CARE - 0027

Pre-monsoon Rainfall Variability over India in Association with MJO and ENSO

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Accurate prediction of Pre-Monsoon Rainfall (PMR) is necessary in India since it bridges the dry winter and the monsoon season. The changes in the interannual and intraseasonal variability of Pre-monsoon rainfall in association with ENSO and MJO in the early (1981- 2000) and recent (2001-2020) epochs is examined here. During the recent epoch, positive rainfall anomalies are observed over southeastern Peninsular India. Over Northeastern parts of India, an enhanced (reduced) rainfall activity during El Nino (La Nina) years is observed in the recent epoch. The PMR across different phases of the Madden-Julian Oscillation (MJO) between two epochs (1981–2000 and 2001–2020) is also examined in detail. During MJO phase 2, positive rainfall anomalies were widespread along the eastern coast in the early epoch but are now limited to southern Tamil Nadu and parts of Odisha. In MJO phase 3, positive rainfall anomalies along coastal Andhra Pradesh and Odisha in the early epoch have diminished recently, while the above normal rainfall is observed in the southern peninsula. In the recent epoch (2001–2020), Southeastern Peninsula witnessed an above normal rainfall during the fourth phase of MJO. During the recent epoch, NE India receives above (below) normal rainfall in the fourth (sixth) phase of MJO, which is exactly opposite to the early epoch.

The observed changes In the rainfall variability In different phases of MJO Is related to the changes In SST, large scale circulation and moisture transport. The decrease in rainfall over eastern coast of India and increase in rainfall over southern tip of India during 2nd and 3rd phase is associated with enhancement of equatorial westerlies over Indian Ocean and the presence of cyclonic circulation over the southern tip of India in the recent years. In the recent epoch, the sea surface temperature (SST) gradient during the fourth phase of the Madden-Julian Oscillation (MJO) – with above-normal SST over the head of the Bay of Bengal (BoB and below-normal SST over the equatorial Indian Ocean- has facilitated the advection of moisture from the Indian Ocean toward northeastern India, thereby enhancing rainfall activity in the region. In the sixth phase of the Madden-Julian Oscillation (MJO),the decrease in rainfall over north-eastern India is linked to shifts in wind circulation patterns over the northern BoB. In the recent epoch, moisture-rich southwesterly winds have been supplanted by dry northeasterly winds, leading to reduced precipitation in the region.

Keywords: Pre-Monsoon Rainfall, MJO, ENSO, SST.

Characteristics of Internal Waves Associated with El-Nino Years in the Northern Bay of Bengal Using Omni Buoy Data – BD08

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ABSTRACT

Internal waves (IWs) are observed in the interior of the ocean due to density stratifications. They are ubiquitous oceanographic feature in the shallow and deep waters of world Ocean. They are generated mainly because of tidal forcing, irregular bottom topography and density stratifications in the Ocean. Internal waves are an important energy source for vertical mixing. Amplitudes of internal waves (tens to hundreds of meters) are depends on the strength of the density stratifications and its frequencies are found to varying from Brunt-Vaisala to inertial. El-nino is referred to climatic events in the ocean which influences on the climatic variability. In addition, El-nino occupy the large warm water area in the upper layers. This will lead to reduce the mixing and results in the large density stratifications in the below layers.

In this paper we investigate the influence of El-nino on the characteristics of internal waves. For this purpose, the time series (Temperature and salinity on hourly basis) data of OMNI buoy (BD08) of two contrasting El-nino years (2012 and 2016) are used. Since the high stratifications are observed during the summer monsoon, the data from the month of August are utilised for this study. It is found that El-nino is having a significant role in characteristics of internal wave activity. During, El-nino year, 2016 more warming in the upper layers, subsequently strong stratification in the water column and it is conducive for large internal wave activity in the thermocline. In addition, the Brunt Vaisala frequency is the highest frequency of internal waves are found to peak (0.05rad/sec) during El-nino year. The depth of occurrence of internal waves are shifted to below 50m depth during El-nino years.

Keywords: Internal Waves, El-Nino, Omni Buoy, Ocean Warming.

Amina Haneef
CARE - 0065

Koottickal Landslide and Mini Cloudburst: A Hydrometeorological Perspective on Extreme Weather Events

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ABSTRACT

The Koottickal landslide of October 16, 2021, exemplifies the devastating impact of extreme rainfall events in Kerala, a state highly susceptible to climate-induced disasters. This study investigates the hydrometeorological triggers and land-use factors contributing to this catastrophic event, emphasizing the spatial distribution of rainfall and its effects on slope stability. The analysis integrates data from Automatic Weather Stations (AWS), the Global Precipitation Measurement Mission (GPM), and ERA5-Land reanalysis to evaluate rainfall patterns, soil moisture, and runoff conditions leading up to the landslide. High-resolution Land Use and Land Cover (LULC) changes in Koottickal Panchayat were downscaled using MODIS data and processed in ArcGIS, enabling a detailed temporal assessment of deforestation and land transformation over the past two decades.

Spatial rainfall analysis revealed a sudden onset of intense precipitation between 9:00 AM and 11:00 AM on October 16, 2021, with rainfall peaking above 30 mm/hour, characteristic of a mini-cloudburst phenomenon. By noon, the intensity had significantly declined, highlighting the short-duration, high-impact nature of the event. Soil saturation and runoff levels reached critical thresholds due to the abrupt deluge, exacerbating slope instability. The downscaled LULC analysis of Koottickal Panchayat revealed a 61% reduction in forest cover and significant increases in plantation and cropland areas over the last 20 years, amplifying the region's vulnerability to hydrometeorological hazards. This study emphasizes the need for advanced early warning systems, high-resolution geospatial monitoring, and community-driven disaster preparedness to mitigate rainfall-induced landslide risks. Sustainable land-use planning is crucial, particularly in deforested regions, to reduce vulnerability. These findings provide critical insights for targeted mitigation strategies and enhancing resilience to future climate-induced disasters in Kerala.

Keywords: Landslides, Mini-cloudburst, Extreme Weather Events, Disaster Risk Reduction, Climate Change Adaptation.

Amita Prabhu
CARE - 0036

Influence of Southern Annular Mode Extremes on Summer Monsoon Rainfall in India and West Africa

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[2]Academy of Scientific and Innovative Research (AcSIR),
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ABSTRACT

This study examines the relationships between the Southern Annular Mode (SAM) and the summer (June-September; JJAS) monsoons in India and West Africa over the past three decades, commencing from the early 1980s. The results reveal significant direct connections, with the January-February SAM positively influencing the ensuing West African Summer Monsoon (WASM), while the February-March SAM is strongly associated with the following Indian Summer Monsoon (ISM). Composites of SAM extremes (negative minus positive) show adverse impacts on summer monsoon rainfall in both regions. The study investigates the pathways of these associations, emphasizing the role of tropical Sea Surface Temperatures (SSTs) in mediating the SAM-monsoon link.

For the delayed response of the ISM, the central Pacific is identified as a key driver, while the Atlantic Ocean plays a crucial role in transmitting SAM signals to the West African region. We propose the following hypothesis: during a negative SAM phase, large-scale atmospheric circulations shift equatorward and interact with tropical SSTs, which persist until the following boreal summer, resulting in below- normal monsoon rainfall. Thus, the evolution of SAM signals from boreal late winter through early spring may serve as potential precursors for predicting the patterns of the subsequent summer monsoons in both West Africa and India.

Keywords: Southern Annular Mode, India, West Africa, Monsoon, Pacific and Atlantic SST.

Diurnal and Spatial Variability of Monsoon Rainfall over the West Coast of India: Influence of Atmospheric Dynamics and Moisture Transport

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ABSTRACT

The west coast of India (WCI) experiences significant spatial and temporal variability in monsoonal rainfall, driven by complex atmospheric dynamics and moisture transport processes. Understanding these variations is crucial for improving regional climate predictions and water resource management. This study aims to analyse the diurnal and spatial characteristics of rainfall over the WCI by categorising rainfall events into three types: offshore, onshore, and uniform. Using the TRMM_3B42 V7 precipitation dataset, along with ERA5 reanalysis, the study investigates the key mechanisms influencing rainfall distribution.

Results indicate that offshore events exhibit peak rainfall over the ocean in the morning hours (05:30-08:30 IST), driven by coastal convergence. Onshore events experience maximum rainfall over the windward slopes of Western Ghat mountains in the afternoon and evening (17:30-20:30 IST) due to orographic uplift and convective processes. Uniform events display a more widespread distribution, with rainfall peaking offshore in the morning and over land at night (20:30-23:30 IST). Zonal wind patterns strongly influence these variations, with offshore events linked to strong westerlies over the ocean, while onshore and uniform events experience inland-penetrating winds, enhancing rainfall over land. Thermodynamic analysis reveals that onshore events exhibit the highest atmospheric instability, supporting intense afternoon rainfall. Overall, this study highlights the crucial role of zonal winds, moisture transport, and topography in shaping monsoonal rainfall patterns along the WCI. The findings improve our understanding of regional precipitation variability, aiding better climate forecasting and hydrological planning.

Keywords: West Coast of India, Diurnal Variation, Onshore and Offshore Rainfall, Dynamics and Thermodynamics, Indian Summer Monsoon.

Angel Anita Christy
CARE - 0009

A Cutting-Edge Wind Profiling Radar for Exploring the Atmospheric Boundary Layer

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ABSTRACT

A very high frequency (VHF) radar operating at 205 MHz has been installed at the Advanced Centre for Atmospheric Radar Research, Cochin University of Science and Technology (CUSAT). The present paper explores the potential of this radar by utilizing the high vertical and temporal resolution data for exploring the Atmospheric Boundary Layer Height (ABLH) and delineating the ABL dynamics. Clear-sky days with simultaneous radar and radiosonde observations were selected to develop a method for estimating the ABLH while ensuring its accuracy. The mixing ratio from the radiosonde and its associated gradient profiles were used to derive reference ABLH values. The proposed method combines the vertical profiles of three parameters – wind direction, wind speed, and signal-to-noise ratio, to estimate ABLH from radar datasets.

The ABLH is determined by identifying the altitude at which the sum of the normalized standard deviations of these three parameters peaks and then drops drastically. A significant correlation ($r = 0.91$ at the 99% confidence level) is found between the ABLH estimated from radiosonde data and that obtained using this method. Unlike radiosonde profiles, which are limited in number, this approach enables the use of radar data to study high temporal variability, including the diurnal and seasonal cycles of ABLH. The potential of the radar for further understanding the ABL and its linkage with triggering local convection, thunderstorms, and sea breeze characterization is also discussed. Nonetheless, certain challenges remain when estimating ABLH in cloudy or wet weather conditions, which require further investigation.

Keywords: ABLH, Radiosonde, VHF Radar, Mixing Ratio.

Anjitha A. C.
CARE - 0020

Fighting Climate Uncertainty: Vulnerability and Resilience in Kerala's Coffee Farming

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ABSTRACT

Coffee, particularly the climate-sensitive Arabica and Robusta varieties, is increasingly threatened by shifting rainfall and temperature patterns, which impact productivity. This study assesses the socioeconomic vulnerability of coffee-growing households in Vythiri, Ambalavayal, and Noolpuzha panchayats in Wayanad district, Kerala. Data were collected from 120 farmers, while secondary climatic data from 1991 to 2022 was obtained from the Regional Coffee Research Station in Chundel. In Wayanad, coffee, black pepper, and arecanut are the main crops, with coffee being the dominant one. Farmers reported a decrease in returns for the 2022-2023 period, driven by irregular rainfall and foot rot disease in black pepper. Using the Just and Pope method, the study found that rainfall variability and farm acreage significantly influence coffee yields. The socioeconomic vulnerability index indicated that Vythiri is highly vulnerable, Ambalavayal is moderately vulnerable, and Noolpuzha is less vulnerable. Key factors contributing to vulnerability included low literacy rates, high use of inorganic fertilizers, limited subsidies, and water scarcity. Ambalavayal also faced challenges like low crop diversification and insufficient support from service agencies like NGOs (Non-governmental organizations). Farm size emerged as an important factor in Vythiri and Noolpuzha's vulnerability.

The study identified 27 climate-resilient practices, with agronomic measures being the most widely adopted, while institutional measures saw the least adoption. Adoption rates were influenced by factors like farm size, farmer experience, and institutional support. The study recommends enhancing irrigation infrastructure through the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), providing localized weather forecasts, implementing weather-based crop insurance, developing disease-resistant black pepper varieties, and promoting soil test-based fertilizer application to reduce vulnerability from climate variability.

Keywords: Coffee, Vulnerability, Climate-Resilient Practices, Socio-Economic Vulnerability Index.

A Critical Analysis of Selected State Action Plans on Climate Change in India

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ABSTRACT

The framing of the National Action Plan on Climate Change (NAPCC) was a watershed moment in India's climate change policy-making. Following the NAPCC, state governments in India were asked to frame their own State Action Plans on Climate Change (SAPCC) for combating climate crisis. However, lack of a clear direction, absence of sufficient participation of various stakeholders, inadequacy of the scientific inputs and the unavailability of funding made many of the SAPCC's almost ineffective. Understanding these limitations in state plans, the Ministry of Environment, Forest and Climate Change of India had asked the states to formulate revised action plans in the year 2018. Now many of the states have given form to their own state level action plans. This paper tries to compare and contrast the state action plans of Kerala, Karnataka, Tamil Nadu and Rajasthan states in India.

While evaluating the policies of different states, many issues were evident in these states' climate policy framing. These issues include challenges in designing and calculating the climate vulnerability index based on the state's unique characteristics, data inadequacy across various sectors and its impact on policy formulation, insufficient stakeholder consultations involving civil society and Local Self-Government representatives, the absence of social scientists in policy development, and the failure to adhere to sound financial principles in climate funding. Though Kerala's climate action plan document fared far better than other states' action plans, it was clear from the study that Kerala's action plan has many limitations as well. This paper would explore the lacunas in Kerala's climate action plan as well in detail. Understanding and assessing the climate performance of states in the country is important in evaluating to what extent the country is moving to achieve its committed emission reduction goals under the Paris Agreement. This paper has employed qualitative methodology in analysing the climate action plans of states and has used official state government documents as primary data for research.

Keywords: SAPCC, NAPCC, Climate Vulnerability, Kerala State Action Plan

Aparnna Ravi
CARE - 0145

Extreme Events – Elucidating the Dynamics of Indian Terrestrial Carbon Uptake Capacity

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ABSTRACT

Terrestrial vegetation absorbs over 30% of anthropogenic CO_2 emissions, aiding in climate change mitigation. However, its carbon uptake capacity fluctuates with climate variability and extreme events, spanning scales from stomatal to continental and across diurnal, seasonal, and interannual timescales. A comprehensive understanding and accurate quantification of vegetation carbon exchange and its response to changing climate at the regional scale are essential for improving policy and decision-making. This study presents a high-resolution, light-use efficiency-based vegetation model for India, which can effectively estimate the terrestrial carbon budget and capture vegetation responses to extreme weather conditions. The Vegetation Photosynthesis and Respiration Model (VPRM) has been modified for the Indian region by integrating new remote sensing products and processes specific to India. Model parameterization typically relies on ground-based carbon flux measurements. However, to overcome their limited availability for representing diverse Indian vegetation, satellite-derived proxies for vegetation physiology and hydro-meteorological parameters are utilized.

Our results show that India acts as a net carbon sink (-0.45 ± 0.05 PgC yr^{-1}), with a photosynthetic uptake of 3.57 ± 0.14 PgC yr^{-1}. Evergreen forests demonstrated the highest carbon fixation efficiency, while deciduous forests acted as a net CO_2 source. The impact of drought was more pronounced in grasslands and croplands, whereas forests were least affected. These findings can aid in regional carbon budgeting, support policymakers in achieving carbon reduction targets, and improve agricultural practices. Moreover, this approach serves as a useful modelling tool for regions with limited reference data to study vegetation carbon dynamics.

Keywords: Extreme Events, Terrestrial Carbon Fluxes, VPRM, Indian Vegetation, Climate Change

Aravindh Panikkaveetti
CARE - 0067

Assessing Vulnerability and Risk to Extreme Weather Events on the Kerala Coast Using IPCC AR4 and AR5 Frameworks

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ABSTRACT

Vulnerability and risk as defined by the IPCC are inherently linked to the adaptive capacities of communities to deal with climate hazards. Kerala's fishing communities are some of the first communities to bear the brunt of hazards like tropical cyclones and tidal floods. Based on an extensive primary survey of 1,271 fishing households across 52 fishing villages in Kerala's nine coastal districts, the current study employs both the IPCC AR4 and AR5 frameworks to assess vulnerability and risk to extreme weather events on the state's coast. The AR4 framework uses a Livelihood Vulnerability Index (LVI) based on exposure, sensitivity, and adaptive capacity, while the AR5 framework adds the hazard angle to the mix. Given the significant role played by the State in Kerala to ensure social and economic equity, both indices incorporate the reach of Governmental policies like social security pensions, employment guarantee programmes, self-help groups, and economic assistance.

The results of the study indicate that Thiruvananthapuram has the highest level of risk and vulnerability in Kerala across the two frameworks, followed by Malappuram and Kollam districts. Kasaragod and Kannur have the lowest values for both indices, and there exists a strong correlation between risk and vulnerability assessment under the two frameworks. The analysis reveals that stronger local-level planning is required in Kerala to address the intra-state disparities in climate risk and vulnerability. Replication of best social welfare practices across the state, and a shift in coastal management practices are likely to reduce the risk and vulnerability of the coastal communities going forward.

Keywords: Livelihood Vulnerability, Risk, IPCC AR4, AR5, Kerala, Coastal Communities.

Exposure to Surface Ozone and Its Associated Health Effects in India for the Year 2022

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ABSTRACT

Surface ozone as a secondary air pollutant, when continuously exposed for 8 hours above a threshold of 70 µg/m³ can often lead to negative health impact. Here, we study the surface ozone variability, the Mean Daily Averaged (MDA)-8 ozone exposure, over India for the year 2022 using satellite and ground-based measurements. Additionally, we also examine the related mortality and relative risk due to ozone pollution in the states and union territories of India.

We observe that mean annual MDA-8 ozone varies between 20 and 30 µg/m³ with slight regional differences. The exposure to surface ozone varies largely between seasons, with a pre-monsoon maximum (30–50 µg/m³) to a winter minimum (<25 µg/m³). Analysis of the mortality related to Chronic Obstructive Pulmonary Disease (COPD) and ischemic heart disease (IHD) shows that the fraction of mortality related to ozone exposure is about 0.8–1 % for the Indian population with a higher cumulative mortality over the urban areas with higher population (about 5000/lakh). Our analysis of relative risk and mortality rate assessment shows that southern states rank highest in the top five priority categories (Karnataka, Kerala, Maharashtra). Consequently, it is imperative to address surface ozone pollution to ensure economic stability, public health and mitigate climate change.

Keywords: Surface Ozone, India, CPCB, Health, Policy, GHG.

Arun P. Thomas
CARE - 0068

Seasonal Variability of PM2.5 and PM10 In Kochi, India: Influence of COVID-19 Lockdowns and Extreme Pollution Events on Air Quality

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ABSTRACT

This study examines the fluctuations in particulate matter (PM2.5 and PM10), using ground-based observational data (January 2018 to March 2023) from the Vyttila Mobility Hub, Kochi, India. The results indicate considerable seasonal variations, with peak PM concentrations observed in winter (December–February) and post-monsoon (October–November), mainly attributed to meteorological factors, including lower planetary boundary layer height (PBLH), temperature inversions, and decreased precipitation. The peak seasonal mean concentrations of PM2.5 and PM10 were recorded in winter at 67.43 ± 17.3 μg/m³ and 106.9 ± 30.02 μg/m³, respectively, whereas the minimum levels occurred during the monsoon (June–September) at 24.10 ± 11.67 μg/m³ for PM2.5 and 54.22 ± 23.58 μg/m³ for PM10. The ratio of peak to lowest monthly mean was 3.3 for PM2.5 and 2.3 for PM10, indicating significant seasonal variations.

During the study period, PM2.5 levels exceeded the National Ambient Air Quality Standards (NAAQS) of 60 μg/m³ on 395 occasions (23% of the time), whereas PM10 levels surpassed the 100 μg/m³ threshold 481 times (28%). During the COVID-19 lockdown (March 24–May 31, 2020), there was a notable reduction in PM concentrations, with PM2.5 and PM10 levels decreasing by 42% and 50%, respectively. The mean PM2.5 and PM10 values for this period were noted as 19.30 ± 12.08 μg/ m³ and 36.32 ± 15.85 μg/ m³ respectively, illustrating the effect of limited human activities on air quality. A significant pollution incident occurred during the Brahmapuram waste plant fire (March 2–14, 2023), resulting in an increase in PM levels. The peak PM concentrations were observed at 9:00 AM on March 4, 463.56 μg/m³ for PM2.5 and 564.79 μg/m³ for PM10. The mean PM levels during fire event (89.60 ± 66.14 μg/m³ for PM2.5 and 131.47 ± 75.24 μg/m³ for PM10) were noticeably higher than the five-year average (52.96 ± 25.54 μg/m³ and 114.16 ± 53.65 μg/m³, respectively), indicating a 69% and 15% increase. The National Air Quality Index (NAQI) exceeded 400 during this incident, revealing serious health risks. These findings highlight the need for stricter emissions regulations, better waste management, and real-time monitoring, along with sustainable urban planning to reduce pollution and protect public health.

Keywords: Air Quality, Particulate Matter, COVID-19, Fire, Kochi.

Features of Rainfall Distribution during Transition from South West Monsoon to Post Monsoon

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ABSTRACT

The Indian subcontinent experiences a bimodal monsoon system characterized by reversal in wind and consequent shift in precipitation patterns. The transition from the Southwest (SW) to Northeast (NE) monsoon represents a critical climatological shift with significant implications in several areas. The SW monsoon (June-September) gradually withdraws from northwest India beginning in September, retreating south-eastward by mid-October. This withdrawal initiates a transitional period marked by shifting upper-air circulation patterns, including the southward migration of the subtropical westerly jet and establishment of anticyclonic circulation over the northern Indian subcontinent. Rainfall patterns undergo major changes during this transition. While the SW monsoon brings widespread precipitation across most of peninsular India with peak intensity along the Western Ghats and north-eastern regions, the NE monsoon (October-December) predominantly affects south-eastern peninsular India, particularly Tamil Nadu, coastal Andhra Pradesh, and parts of Kerala and Karnataka. The band of rainfall migrates from south-west to north-east.

Transition from SW to NE monsoon starts in September, usually starting from north-western India (typically from Rajasthan) in early to mid-September and progresses in a south-eastward direction. This transitional period continues through October as the SW monsoon completely withdraws from the Indian subcontinent. The North-east monsoon typically establishes itself by mid-October. Recent climatological analyses suggest a trend towards variability in onset and intensity, which may potentially be linked to broader climate change patterns and teleconnections including ENSO and IOD events. Precipitation characteristics also transform markedly, with SW monsoon rainfall characterized by consistent moderate-intensity events, while NE monsoon precipitation tends toward fewer but more intense rainfall episodes, often associated with tropical cyclonic disturbances in the Bay of Bengal. This study analyses the micro-regional characteristics of the transition period from SW to NE monsoon. The shifting of the transition zone from south to north and to south again, the time period for the complete setting in of NE monsoon are studied. The time period when NE monsoon reaches its peak value, regions of maximum rainfall, the maximum amount of rainfall in those regions, as well as the teleconnection between ENSO and monsoon season is also analysed.

Keywords: ENSO, Rainfall, Monsoon Transition.

Ashish Shaji
CARE - 0019

Convective Chaos: How Climate Change Electrifies Indian West Coast?

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ABSTRACT

A warming planet is widely recognized to increase lightning activity, posing significant risks to life and property. While the west coast of India (WCI), one of the most densely populated regions, historically experienced relatively low lightning activity during the monsoon season (June to October), recent trends reveal a notable rise in lightning flash counts, particularly in the southern part of the peninsula compared to the north. By analysing a 26-year dataset (1998–2023) of atmospheric variables, including lightning observations from TRMM OTD/LIS sensors, we identified a growing trend in lightning activity linked to deep convective clouds over southern WCI, contrasted with a slight decline in the north.

Although previous studies have revealed increasing convective activity over the WCI during the monsoon, our findings highlight the southern WCI as a region of heightened concern. Rising surface air temperatures and sea surface temperatures (SSTs) are fuelling deeper convection in an unstable atmosphere, as evidenced by increased moist static energy. This, in turn, favours an increase in ice/graupel concentration responsible for charge production and lightning discharge. These results underscore the urgency of climate adaptation, calling for early preparedness and disaster mitigation measures to address the growing exposure and vulnerability of communities in the region.

Keywords: Climatology, Lightning, Convection, Precipitation.

Drought Management in Rice Using Foliar Applicants

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ABSTRACT

Drought affects yield as well as biochemical, physiological and morphological functioning of plant. Drought will affect not only rice yield but also will shift cropping systems away from rice cultivation towards more cultivable crops with adequate temperature range. Therefore managing drought for sustaining rice cultivation and yield is very important. This study was done to make an attempt to alleviate ill effects of drought stress on rice and to sustain the rice yields by extraneous application of foliar sprays. An experiment was conducted at Instructional Farm of Kerala Agricultural University, Vellanikkara during late Rabi 2024 with the objective to manage drought in rice using foliar applicants. The mean average temperature was above 40^0 C and there experienced a rainless period for over 100 days. The crop days was exposed to high temperature up to maturity stage. Medium duration rice variety Uma was used for the study.

The experimental design followed was factorial CRD with three replication. Treatments consisted of 7 foliar applicants viz., F1 – PPFM 1-2% (Pink Pigmented Facultative Methylotrophs), F2 – Salicylic acid 200 ppm, F3- Kaolin @ 5%, F4- KCl 0.3%, F5 – Silica(Ksi2O3) 400 mg/L, F6- Water spray, F7- Control (without any applicants) and 3 moisture stress levels viz., I1 – 50% FC (at all growth stages), I2 – stress at maximum tillering (MT) and panicle initiation(PI) stage, I3 – no moisture stress (water was given at field capacity throughout the growth stage). Foliar sprays were given at two growth stages one at maximum tillering (28 DAS) and the other at panicle initiation stage (55 DAS). Growth parameters such as plant height, leaf area, root length, shoot length, fresh root weight, dry root weight, fresh shoot weight, dry shoot weight etc were observed at 30, 60 and 90 DAS. Yield parameters such as panicles per plant, grains per panicle, grain yield, 1000 grain weight and straw yield was recorded. DAB staining for H2O2 and NBT staining for ROS was done using light microscopy. Results of the study indicated that foliar application had a significant influence on managing drought under moisture stress situation. Growth parameters such as plant height, root length, fresh shoot weight, dry shoot weight, root biomass and dry matter production was significantly influenced by foliar spray.

Due to the application of foliar applicants rice yield at 50 % FC moisture stress showed significant variation. At 50 % FC moisture stress KCl applied @ 0.3% and Kaolin @ 5% increased yield by 46.23% and 41.84% respectively when compared to treatments without

any foliar spray. This could be due to stress relieving characteristic of potassium chloride and also the solar radiation reflecting character of kaolin antitranspirants. Under irrigated conditions application of kaolin @ 5% observed the highest yield compared to other amendments and this treatment recorded yield increase by 42% when compared to absolute control. This was closely followed by application of Silica (Ksi2O3) @ 400 mg/L and KCl @ 0.3%. For plants exposed to stress at MT and PI stage, similar trend as of irrigated condition was observed. After staining with DAB to find H2O2 accumulation and NBT to find the ROS (Reactive Oxygen Species) from stress it was found that more stain was in control and least in KCl followed by kaolin treatments signifying less accumulation of ROS species. Many findings have shown ROS spicies accumulation is more in plants due to stress either moisture stress or salinity stress. Here less stain was observed in KCl and Kaolin indicating plants are less stressed due to the foliar spray. From this study it could be concluded that application of kaolin @ 5 % and KCl @ 0.3 % is capable of alleviating stress efficiently and it could be recommended to farmers of Kerala under water stress situation.

Keywords: Drought Stress, Foliar Application, KCL, Kaolin, Rice Yield.

Aswathy K. Vijayan
CARE - 0055

Assessing Forest Fire Dynamics in Attappady, Kerala: Innovations in Disaster Risk Reduction and Ecological Resilience

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ABSTRACT

Forest fires were a major challenge to ecosystem stability, carbon sequestration and community livelihoods. Attappady forest range in Western Ghats of Kerala had recurring fire events and needed scientific intervention and proactive risk management. As per Forest Survey of India and Kerala Forest Department reports, Kerala had 457 forest fire incidents in 2023 affecting 901.51 hectares and 374 in 2024 affecting 568.05 hectares. Though the number of incidents decreased, the region was still vulnerable. This study used remote sensing and geospatial analytics to assess fire severity, ecological impacts and greenhouse gas emissions and identify the triggers. Also, interactions with forest officials provided insights into the fire management strategies implemented in Attappady region. Landsat satellite imagery was used to assess pre and post fire condition using burned indices, biodiversity metrics and land use land cover (LULC) changes.

In 2024, Attappady recorded 6.5 sq km of burned area, including 2.87 sq km in reserve forests and 3.63 sq km in vested forests, categorized as low severity fires. The mild severity of the fire resulted from enhanced fire management techniques such as early detection, managed burning, and greater community participation in fire prevention. NBR decreased from -0.50 pre fire to -0.11 post fire indicating vegetation recovery due to effective mitigation. NDVI declined from 0.56 to 0.54 suggesting reduction in vegetation cover. LST increased from 65.73°C to 75.39°C probably due to loss of canopy cover. Greenhouse gas emissions decreased with CO2 from 10.18 to 8.08 kg ha-1, CH4 from 0.04 to 0.039 kg ha -1and CO from 0.72 to 0.57 kgCO due to low intensity fires and post fire regeneration. This research improved disaster risk reduction by combining ecological, atmospheric, and geospatial information to enhance fire forecasting, mitigation planning, and evidence-based policy actions for Kerala's forest conservation and Attappady's long-term resilience.

Keywords: Forest Fire, Attappady, Remote Sensing, Disaster Risk Reduction, Ecological Resilience.

Athira Baby
CARE - 0024

Studies on Enhanced Lightning Activity over the Lightning Hotspot of India

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ABSTRACT

Lightning is a natural electrical discharge phenomenon that occurs between cloud and the ground or between the clouds. It is an intense phenomenon that has the potential to cause great harm, uncertain conditions, and even fatalities. In this study, five years of lightning observation data from the IITM Lightning Location Network are used to determine seasonal and spatial variations of Intra-Cloud, Cloud-to-Ground and total number of lightning strikes over different geographical locations of the Indian landmass.

Lightning activity is found to be more frequent during the pre-monsoon and monsoon seasons in certain region and the region with significant number of lightning occurrences is identified as a lightning hotspot. The enhancement of lightning activity over hotspot region is examined in relation to various atmospheric and surface parameters, and the combined effect of these factors on lightning occurrence is analysed to understand the environmental conditions that contribute to high lightning activity.

Keywords: Lightning, IITM Lightning Location Network.

Athira Saleevan
CARE - 0116

Impact of Forest Fire on Soil Systems in Southern Western Ghats, Kerala

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ABSTRACT

Climate change events have increased drastically across the globe. India recorded highest number of heat wave days for the last 14 years in 2024, which eventually can contribute to amplified forest fire occurrences. This in turn impact the soil health severely by altering soil structure, reduced water infiltration and land erosion. According to satellite data for 10 years, 39% of Kerala's Forest are prone to fire. Even though this number is not so large in comparison to other states, Fragile nature of western ghats makes it a matter of concern. Frequently fire affected and unaffected areas in moist deciduous forests of Peechi-Vazhani wildlife sanctuary was selected for the study. Soil samples were collected at five equal depths (0-20, 20-40, 40- 60, 60-80 & 80-100) up to 1m in toposequence. Analysis of natural forest soils revealed the acidic nature of both fire affected and unaffected soils.

When sandy clay was found as the most common texture of the soil in five equal depths of unaffected soils, those affected by fire were with sandy clay loam texture. Proportion of sand was comparatively higher in soils affected by fire than (71.17 ± 4.81 to 69.17 ± 5.81) that of unaffected soils (63.17 ± 2.67 to 65.17 ± 0.67). Similarly, clay percentage was more in soils which were not affected by fire (30.83 ± 1.76 to 30.83 ± 0.67) than fire affected one (22.16 ± 3.06 to 26.16 ± 4.62). Organic carbon content decreased from top to bottom layer in both the fire affected (2.13 ± 0.39 to 0.62 ± 0.19) and unaffected soils (1.85 ± 0.24 to 1.02 ± 0.26). At the same time, the increased organic carbon content was restricted to the top layer of fire affected soils and it decreased with depth. Thus, notable differences in soil properties were observed between fire affected and unaffected soils. Therefore, further studies are essential to learn about the soil dynamics with fire regimes and the consequent effects on the ecosystems.

Keywords: Forest Fire, Western Ghats, Kerala, Soil Parameters.

Athira U. N.
CARE - 0104

Characteristics of Weather Extremes Over Arabian Peninsula

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ABSTRACT

This study investigates extreme weather events over Qatar, a country in the Arabian Peninsula. It is divided into two parts: one focusing on temperature extremes and the other on rainfall extremes.

The first part examines heatwave events over the past 20 years (1994–2023), focusing on the role of land-atmosphere interactions and large-scale atmospheric circulation in intensifying extreme heat. A composite analysis of soil moisture and soil temperature anomalies reveals significant land surface drying, which reduces evaporative cooling and amplifies surface heating. At upper levels, strong divergence and positive geopotential height (GPH) anomalies reinforce large-scale subsidence, suppressing convection and increasing solar radiation at the surface. Concurrently, anomalous advection of hot, dry air at lower levels depletes soil moisture, further intensifying surface warming. Vertical velocity anomalies confirm widespread descending motion across all levels, establishing a feedback loop that prolongs heatwave conditions. These findings underscore the strong coupling between atmospheric circulation and land surface processes in driving extreme heat events.

The second part of the study explores the long-term (epochal) variability of extreme rainfall over Qatar, focusing on 10 mm rainfall events over the past 75 years (1950–2024). Analysis of the ratio of total rainfall to 10 mm events indicates an overall increasing trend in rainfall, except during the global warming hiatus period, after which the trend resumes. The study further divides this period into three epochs of 25-year period: 1950–1974, 1975–1999, and 2000–2024. A notable northward shift in heavy rainfall events has been observed in recent years. Further, the study is focusing on Qatar's wet season (from November to April), which is further divided into two sub-periods: November–January and February–April. Detailed understanding these long-term variability patterns and associated mechanisms is essential for improving extreme weather prediction and mitigation strategies in a warming climate.

Keywords: Weather Extremes, Heat-waves, Extreme Rainfall, Climatology.

Avinash Paul CARE - 0117

A Case Study of the Longest-Lasting Marine Heatwave in the South-East Arabian Sea

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ABSTRACT

The South-East Arabian Sea (SEAS), off India's southwest coast, has warmed dramatically since the 1980s due to climate change and monsoon shifts, fueling intense cyclones, extreme rainfall events. In recent decades, marine heatwaves (MHWs) have become more intense in this region; the most prolonged MHW on record, which lasted 78 days and peaked at 1.5°C above the climatological threshold, was recorded in 2016. In this study we combine satellite derived SST and reanalyses products to characterize the temporal and spatial evolution of this longest extreme warming event. Further we investigate the underlying atmospheric and oceanic drivers contributing to this unprecedented prolonged MHW event.

This case study provides valuable insights into the dynamics of prolonged MHWs in the Arabian Sea, enhancing our understanding of their potential consequences for marine environments and contributing to improved predictions of future extreme warming events in the region. The 2016 event exemplifies the escalating threat of MHWs under climate change. By isolating the physical factors, the current research informs strategies to mitigate risks to coastal industries and infrastructure, emphasizing the urgency of emissions reduction and adaptive ocean governance.

Keywords: Marine Heatwave, South-East Arabian Sea, Prolonged Oceanic Extremes.

Balasundhar B. V.
CARE - 0023

Comprehensive Evaluation of Aeolus Wind Products Against In-Situ Observations and Re-Analysis Datasets over the Indian Monsoon Region

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ABSTRACT

Several ground-based and balloon-borne instruments are available for wind measurements, but their coverage is limited only to a particular location. At this juncture, the launch of the Aeolus satellite by the European Space Agency (ESA) on August 22, 2018, equipped with the first Doppler wind lidar instrument in space, ALADIN (Atmospheric Laser Doppler Instrument), which emits laser pulses of UV light at a wavelength of 354.8 nm, made it possible to obtain wind profiles globally throughout the troposphere and lower stratosphere. The Aeolus satellite provides the Horizontal Line of Sight (HLOS) wind in Rayleigh and Mie channels. In this study, an initial comprehensive validation of the ascending and descending Aeolus L2B wind products in these two channels was conducted using GPS radiosonde observations launched at 00 UTC and 12 UTC over India Meteorological Department (IMD) locations from June 2019 to October 2022.

A comparison of the Aeolus HLOS winds was also made with global (ERA-5 from the European Centre for Medium- Range Weather Forecasts [ECMWF]) and regional (IMDAA: Indian Monsoon Data Assimilation and Analysis reanalysis - from the National Centre for Medium Range Weather Forecasting) reanalysis datasets. The retrieval assessment is also performed by segregating these winds into different seasons like pre-monsoon, monsoon, post-monsoon, and winter. The results show a good correlation between Aeolus and in-situ wind measurements, with a correlation (bias) of 0.72 (1.35 m/s) for Rayleigh-clear and 0.66 (3.98 m/s) for Mie-cloudy retrievals. Similar biases were observed, with differences in magnitude when compared to reanalysis datasets. This study quantifies wind measurement biases over the Indian monsoon region, enabling their direct assimilation into WRF models to enhance weather forecasting accuracy.

Keywords: Aeolus, IGRA, ERA5, IMDAA, Wind Validation.

Betsy K. B.
CARE - 0082

Role of Aerosols on Prolonged Extreme Heatwave Event Over India and Its Implication to Atmospheric Boundary Layer

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ABSTRACT

The extreme heatwave condition is a major threat to living beings in the warming climate which demands immediate quantification of the meteorological factors triggering its amplification. In this study, we explored the role of absorbing and scattering aerosols in the occurrence of extreme heatwave conditions as well as changes in the atmospheric boundary layer (ABL) over the northwest (NW) and east coast (EC) India during March-June 2017-2022. Ten dry (RH < 33%) and nine moist (RH > 55%) heatwaves conditions are observed over the study period.

Among these cases, a dry heatwave over NW region prolonged from 27 May to 11 June 2019 is explored in detail. In this case, the increased ABL height from ~2.0 – 3.0 km to ~4.0 – 5.0 km is observed and the entire ABL depth shows enhanced temperature by ~ 4 K. The latent and sensible heat fluxes are found to be reduced by 50 W/m^2 and enhanced by 80 W/m^2 respectively during heatwave. The total aerosol optical depth (AOD) is gradually enhanced to 0.6 leading to enhanced atmospheric warming of ~8.5-11.5 W/m^2 during the heatwave condition. Furthermore, the heating rates for moist heatwave cases (~2 K/day) are higher than those for dry heatwave cases (~ 1.8 K/day). In addition, the moist heatwaves exhibit a higher concentration of PM2.5 (~80- 120 µg/m^3) compared to the dry heatwave (~60-100µg/m^3) posing a greater threat to public health and air quality.

Keywords: Heat-waves, Aerosols, Boundary Layer.

Bichu B.
CARE - 0107

Increasing Intensity of Potential Meso to Synoptic Scale Low Pressure Systems in the North Indian Ocean: Need of An Effective Early Warning System for South-West Coast of India.

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ABSTRACT

The study of tropical cyclone activity in the North Indian Ocean, which includes the Bay of Bengal and the Arabian Sea, from 1982 to 2022, reveals significant changes in cyclone frequency, intensity, and duration. Over the past four decades, the region has seen an increase in the frequency of tropical cyclones (TCs), raising concerns about the shifting dynamics of atmospheric and oceanic processes that drive cyclone formation. This rise is primarily linked to rising sea surface temperatures and changing weather patterns, both influenced by climate change. Interestingly, while the Bay of Bengal, historically the more cyclone-prone region, has shown a slight decrease in cyclone numbers, the Arabian Sea has experienced a notable increase. This shift is particularly significant because the Arabian Sea has traditionally seen fewer cyclones than the Bay of Bengal.

The Increase In cyclones in the Arabian Sea Is likely driven by warmer sea surface temperatures and changes in atmospheric circulation, highlighting the profound impact of climate change on regional weather patterns. Alongside the increase in frequency, there has also been a rise in the intensity and duration of these storms. Our study introduces the sum of T number weighted active cyclone hours (sTWACH), a metric designed to measure both the intensity and duration of cyclones. This analysis shows that cyclones are not only becoming more frequent but are also lasting longer and reaching greater intensities, particularly in the Arabian Sea. The growing intensity and persistence of cyclones point to the escalating challenges posed by these storms, especially as climate change makes conditions more favorable for their formation and intensification. The study's findings have important implications for millions of people living in the coastal regions of the North Indian Ocean. With cyclones becoming more frequent and intense, the risks of severe weather events and significant damage increase. The rise in cyclone activity in the Arabian Sea is especially concerning for coastal communities in that region, which may not be as prepared as those in the Bay of Bengal, where cyclone preparedness is better established. This research emphasizes the need for improved monitoring, forecasting, and preparedness to protect vulnerable communities. Additionally, building a robust early warning system is crucial for ensuring timely interventions to save lives and livelihoods.

Keywords: Climate Change, North Indian Ocean, Cyclone Intensity, Cyclone Frequency.

Breanila Paul A.
CARE - 0096

Marine Heatwaves in the Arabian Sea: El Niño's Influence and Monsoon Season Dynamics

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ABSTRACT

Marine heatwaves (MHWs) are prolonged periods of abnormally high sea surface temperatures (SST). MHW day (MHWD) is defined as a day when the SST exceeds the daily 90th percentile. The Arabian Sea, located between the Middle East and the Indian subcontinent experiences seasonal changes in ocean temperatures, influenced by the monsoon and phenomena like El Niño. El Niño is a climate phenomenon characterized by the warming of the central and eastern Pacific Ocean, which can have far-reaching effects on global weather patterns. During El Niño events, ocean temperatures in the Arabian Sea may rise, leading to more frequent or intense marine heatwaves. For the detection of MHWs, a set of different metrics are reported that characterize every single event. Main primary metrics such as event duration, mean and maximum intensities have been selected to run the analysis.

This study shows the characteristics of MHW events for the Arabian Sea during 1982–2024. The analysis showed that the duration (frequency) of MHWs exhibits a rapidly increasing trend in northern Arabian Sea. The southwest monsoon significantly impacts the climate of the Arabian Sea region. During El Niño years, the monsoon can become weaker or delayed, which may allow marine heatwaves to develop more frequently or intensely. The marine heatwaves in the western Indian Ocean was found to result in dry conditions over the central Indian subcontinent. This study underscores the growing importance of understanding the interplay between El Niño, marine heatwaves, and the monsoon, particularly in the context of climate change, to better predict and mitigate future risks to the region's marine ecosystems and economy.

Keywords: Marine Heatwaves, Sea Surface Temperature, Arabian Sea, El Niño.

Chandana B. Jyothi
CARE - 0100

Modeling the Future of Rice Cultivation in Central Kerala: Climate Change and Yield Projections

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ABSTRACT

Agriculture is highly vulnerable to climate variability, making crop production increasingly affected by climate change. Rice, a staple crop in Kerala, is particularly sensitive to shifting climatic conditions, posing challenges for farmers and policymakers. Adverse weather and long-term changes disrupt productivity, necessitating predictive models to assess risks and develop adaptive strategies. To address these challenges, this study employs global climate models (GCMs) to project changes in key weather parameters under two climate scenarios: SSP2-4.5 (moderate emissions) and SSP5-8.5 (high emissions), based on CMIP6 (Coupled Model Intercomparison Project Phase 6) data. The analysis focuses on the central zone of Kerala, evaluating the potential impacts of climate change on rice production. Two short duration rice varieties, Jyothi and Manu Ratna, were assessed across two timeframes, mid-century and end-century. Future climate trends were analyzed using the Mann– Kendall (MMK) test, revealing an increase in maximum temperature during certain months that will coincide with the panicle initiation and flowering stage of rice. Rainfall showed an increasing trend in the midcentury under both the climate scenarios and in the late centuries under high emission scenario. The Decision Support System for Agrotechnology Transfer (DSSAT) was utilized to simulate rice phenology and yield responses under projected climate scenarios.

The results indicate a reduction in crop duration and yield for both rice varieties across all future periods compared to the baseline, with a more pronounced decline in yield for early plantings than late-season plantings. The projected temperature had a significant negative impact on rice duration in the future and it may cause a reduction in the crop duration from present to future conditions. These findings highlight the potential risks climate change poses to rice production in Kerala and emphasize the need for adaptive measures. The study provides valuable insights for policymakers and agricultural stakeholders to develop climate-resilient strategies, ensuring sustainable rice cultivation in the face of future climatic uncertainties.

Keywords: Rice Production, Climate Change, DSSAT, Yield Prediction, Global Climate Models (GCM).

Deepak Gopalakrishnan
CARE - 0143

Subtropical Jet Dyanmics and Arabian Rainfall: A New Perspective

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ABSTRACT

Wintertime rainfall events in the Arabian Peninsula (AP) are influenced by interactions between extra-tropical systems originating from the Mediterranean region and tropical weather systems. However, the complete sequence of events leading to heavy precipitation remains unclear, particularly the role of the subtropical jet. The present study employs a 17-year-long simulation using the Weather Research and Forecasting (WRF) model at 9-km grid spacing to investigate the mechanisms involved in wintertime rainfall events over the AP.

The analysis based on the composites of rainfall events reveals that the equatorward extension of the upper-level jet, combined with embedded upper-level troughs, generates mid-level vorticity and anomalous lower-level convergence. This in turn leads to the development of a surface low that is enhanced by the Red Sea trough, displacing the persistent anticyclone eastward into the Arabian Sea. This shift facilitates the transport of warm, moist air from the Arabian Sea and Red Sea, which converges with cold, dry air from mid-latitude region, initiating convection. We test the proposed mechanism utilizing semi- idealized numerical experiments by modifying upper-level wind, and demonstrate that a strong, southward intrusion of upper-level jet can indeed lead to precipitation over the AP.

Keywords: Subtropical Jet, Precipitation, Arabian Peninsula, WRF Model.

Dhanya Joseph
CARE - 0076

Rising SST and Sea Level Variability: A Growing Risk for India's West Coast

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ABSTRACT

The present study explores the relationship between sea surface temperature (SST) and sea surface height (SSH) along the west coast of India (68°E-78°E, 5°N-22°N) using the bias-corrected CMIP6 model projections. The analysis is based on historical model corrections using observational and reanalysis data for SST and SSH, with a baseline period from 1985 to 2014 and projections extending up to 2099. Long-term trends and seasonal correlations were explored to assess the influence of SST variations on SSH changes.

Results indicate a consistent positive trend in both SST and SSH, highlighting a strong connection between ocean warming and sea level rise. Seasonal correlation analysis reveals the highest correlation (> 0.8) during the monsoon season (June-September, JJAS), followed by the post-monsoon season (October-November, ON), where correlations exceed 0.7 for SSP1 and 0.8 for SSP2, SSP3, and SSP5. For every 1°C rise in sea surface temperature, sea levels are expected to increase by 4-5 cm along the west coast. Furthermore, the rates of SST and SSH increase are found to be 0.19°C to 0.30°C and 0.5 cm to 1.2 cm per decade respectively, in selected SSPs for the near future up to 2050. These findings underscore the significant role of monsoonal dynamics, thermal expansion, and regional ocean- atmosphere interactions in shaping future sea level changes along the west coast of India. Understanding these relationships is crucial for assessing coastal vulnerability and developing adaptive strategies to mitigate the impacts of climate change in the region.

Dharmadas Jash
CARE - 0034

Predicting Thunderstorm Evolution Using Deep Learning Models with Doppler Weather Radar Observations

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ABSTRACT

Thunderstorm (TS) is a severe weather phenomenon develops mainly due to intense convection and accompanied by heavy rainfall, thunder and lightning. Usually, these thunderstorms have spatial extent of a few kilometres and life span less than an hour. However multi-cell thunderstorms developed due to organized intense convection may have a life span of several hours and may travel over a few hundreds of kilometres. Nowcasting of such storms are extremely important as they cause casualties mainly due to lightning strikes. In this study we have used data from a C-band Doppler weather radar (DWR) installed at Space Physics Laboratory (8.52N, 76.89E), Trivandrum (southern tip of India). We have utilized deep learning (DL) models with Generative Adversarial Network (GAN) to predict evolution of pre-monsoon thunderstorms over southern peninsular India. MAXZ reflectivity data of thunderstorm events during pre-monsoons of 2018-2024 have been used for training and testing of the DL models. Total 4 models have been used.

For 15 & 30 minute ahead predictions the MAE for the test samples are about 0.8 dB and 1.2 dB respectively. Evolution of the thunderstorm system on 13-May-2018 has been studied in detail. Movement of the system has been tracked by following centre of the largest cluster of high reflectivity (Z > 40 dBZ) values. All the four models were able to capture the overall spatial patterns of the reflectivity field well. For 15- minute ahead predictions, the models predict the movement of the centre reasonably well. The scatter plot between the direction of true movement & predicted movement of the centre are well correlated. Similarly, the scatter plots between the actual distance travelled & predicted distance travelled by the centre are well correlated though there is a negative bias. The study demonstrates the ability of the deep learning models in predicting the evolution the thunderstorms. With increase in the number of training samples in future, these predictions are expected to improve further.

Keywords: Thunderstorm, Radar, Deep Learning

Offshore Windfarms and Underwater Noise Proliferation

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ABSTRACT

The demand for renewable energy facilitated the large scale installation of offshore wind farms. Wind turbine convert wind energy into electricity and oceans have been identified as the potential zone for wind farms due to the presence of consistent and strong wind patterns. In India, two wind farms are now being proposed at off Gujarat and Tamil Nadu. However the decadal studies indicate that due to anthropogenic activities the underwater noise levels are increasing into an alarming situation. Since most of the marine species relay on sound in their natural habitat this noise proliferation disrupt their echolocation, feeding, mating and even the migration patterns. The performances of acoustic instruments are also got degraded due to the increased noise levels. Conversely the effect of wind farms on underwater soundscapes has been evaluated in a couple of studies and reveals that noise levels are contributed by the three stages of its life cycle: construction, operation and decommission. The construction phase produce most insensitive noise levels added from the pile driving, seabed drilling and supporting vessel traffic.

An impact study which was conducted at Bay of Bengal, reported a noticeable difference in the fish chorus patterns during the pile-driving in 0.05-1kHz frequency band. The repercussions on marine mammals are mostly evident in the form of impaired hearing and hearing threshold shift. During the operational stage of a wind farm, the spinning blades and internal gear box produce long-term continuous noise in the low frequency band (<200Hz). To mitigate these impacts, together with the appropriate environmental impact assessments, some strategies need to be implemented. Through continuous noise monitoring networks it is possible to quantify the underwater noise levels, which is critical for documenting the change and providing input to management and legislation. Strict global initiatives have been launched to maintain standards and regulate the use of sound in ocean. A review of such mitigation strategies are attempted in this study. It is recommended that the bubble curtains, quieting technologies and utilizing the seasonal variation in sound propagation conditions can minimize adversarial effect of offshore wind farms on marine ecosystems.

Keywords: Underwater Soundscape, Offshore Wind Farms, Policy Making, EIA, Noise Pollution.

Fathima Kamarudheen
CARE - 0075

Evaluation of Trend Analysis Methods Using IMD Dataset (1901 to 2023) over India

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ABSTRACT

Analysis of rainfall characteristics over the past century offers valuable insights into rainfall variability, especially during the Indian summer monsoon months from June to September. This study thoroughly examines India's annual and seasonal rainfall trends spanning 122 years, from 1901 to 2023. It utilizes the Indian Meteorological Department (IMD) daily gridded rainfall dataset, compiled from 6,955 rainfall measuring stations across the Indian region, with a spatial resolution of 0.25° × 0.25°. To investigate long-term trends, the study statistically analyses accumulated annual rainfall and seasonal rainfall for the pre-monsoon (March to May), monsoon (June to September), and post-monsoon (October to November) periods for each year. Three commonly used methods for trend analysis are employed: linear regression, Mann-Kendall's and Sen's slope test, and innovative trend analysis.

The results indicate that India's Northeast and Southwest regions receive higher levels of annual and monsoon rainfall than other areas. During the pre-monsoon season, Northeast India receives more rainfall than other regions, while South Indian regions experience greater rainfall during the post-monsoon season. The spatial trend patterns observed through different analysis methods are largely consistent. At the country scale, the analysis suggests that there are no significant trends in annual and seasonal rainfall, except for the pre-monsoon season, which shows an increasing trend in precipitation, whereas significant increasing and decreasing trend patterns could be seen spatially This study provides essential insights into India's climatic behaviour, emphasizing regional rainfall variations and long-term trends, with important implications for meteorology, climate science, water resource management, agricultural planning, and climate change adaptation.

Keywords: Indian Rainfall - Seasonal & Annual, Rainfall Trend, Trend Analysis Methods.

Coastal Disaster Risk Reduction and Community Resilience: A Case Study from Thalikkulam Panchayat

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ABSTRACT

Coastal regions worldwide face increasing threats from climate change-induced hazards such as sea level rise, storm surges, coastal erosion, and extreme weather events. This study assesses disaster preparedness, risk perception, and adaptation strategies in the coastal communities of Thalikkulam Panchayat, Kerala, India. Through socio-economic surveys, water quality assessments, and disaster risk analysis, this research identifies vulnerabilities and proposes strategic interventions for sustainable coastal management.

The findings highlight that while 87% of the population receives disaster warnings, 13% remain uninformed. Although 88.9% of residents are aware of natural disasters, 11.1% lack awareness. Despite the availability of mitigation guidelines, only 78.76% of the population understands emergency response measures. Moreover, water quality analysis indicates significant contamination risks, with pH levels varying from 8.08 to 9.44 and conductivity ranging from 206 to 804 µS, posing health concerns. Key recommendations include strengthening early warning systems, improving evacuation routes, enhancing public awareness campaigns, and implementing community-based coastal protection measures. This study underscores the urgency of integrating scientific approaches with local knowledge to enhance resilience and reduce coastal disaster risks in Kerala's vulnerable coastal belt.

Keywords: Climate Change, Coastal Disasters, Disaster Risk Reduction, Resilience.

Aerosol Inhibition on Photochemical Surface Ozone Formation Under Future Climate and Air Quality Scenarios

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ABSTRACT

Aerosols significantly influence tropospheric oxidation and ozone formation by modulating photolysis rates and radical sinks. This study employs the GEOS-Chem model to analyze different aerosol heterogeneous uptake coefficients (0, 0.1, 0.2, 0.4) and their effects on photochemical ozone levels across global regions under future Shared Socioeconomic Pathways (SSP) scenarios.

Lower uptake coefficients lead to an increase in the concentration of radical species like HO2 and reduce the extent of aerosol-inhibited regime (AIR) in regions like India and East Asia which are currently within AIR, leading to a notable increase in surface ozone (40–50%), especially during colder months. Projections for 2046 indicate a global reduction in AIR areas, resulting from stricter emission controls. By 2096, the extent of AIR further diminishes, with regions such as Southeast Asia transitioning to NOx-limited conditions, though aerosol uptake of HO2 continues to elevate surface ozone levels by 10–15% in heavily aerosol-loaded areas.

Keywords: Ozone, Aerosol, Heterogeneous Chemistry, SSP, UNSDG.

Harikrishnan Namboothiry N.
CARE - 0013

An Analysis of Urban Heat Island Phenomena in the Urban Agglomerations of Ernakulam and Thiruvananthapuram Districts of Kerala

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ABSTRACT

India is one among the major economies witnessing rapid urbanization in the developing world. Kerala is one of the states in India witnessing a faster urban growth. Ernakulam and Thiruvananthapuram, known as the economic capital and the capital of Kerala respectively, are two of the rapidly urbanizing districts in the Kerala. Urbanization alters the land-use patterns of the place, causes ecological and environmental changes which ultimately attributes to the climate change. The phenomenon called the Urban Heat Islands (UHIs) are one of the impacts caused by urbanization which increases the temperature of urban area compared to its surroundings. As urbanization is one of the inevitable symbols of development, it is crucial to study the environmental impacts due to urbanization which helps in adopting sustainable practices and implementing effective urban planning to mitigate the adverse effects.

This study focuses on using remote sensing techniques to study the land cover (LC) changes, evolution of Surface UHIs (SUHIs) and its correlation with the health of the vegetation in the urban agglomerations of the districts – Ernakulam and Thiruvananthapuram – in the state of Kerala. The MERIS data provided by the European Space Agency (ESA) was utilized for studying LC and MODIS data provided by NASA was used to study the changes in Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI). The data from 2001 to 2022 were taken and analyzed in detail. The study reveals the evolution and enhancement of UHIs across the urban agglomerations in both the districts. The UHI dynamics of both the places were found to be negatively correlated to the NDVI. The study signifies the urgent need of proper urban planning incorporating more green spaces in the cities of Ernakulam and Thiruvananthapuram.

Keywords: Urban Heat Islands, Urban Climatology, Land Use Changes, Urbanization.

Harinandana M. S.
CARE - 0111

Urban Heat Island: A Climatological Perspective

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ABSTRACT

This study explores the long-term spatial and temporal trends in urban heat island (UHI) intensities across Delhi from 1979 to 2023. Rapid urbanization has notably amplified UHI effects, especially at night, due to the thermal inertia of urban surfaces. In cities like Delhi, rising UHI intensities are primarily driven by land use changes and anthropogenic heat emissions. The study also underscores the significance of wet-bulb temperature (WBT) in assessing heat stress in urban environments, particularly in semi-arid regions. Increasing WBT anomalies in urban areas like Delhi highlight growing public health concerns stemming from the combined impact of rising temperatures and humidity.

The analysis examines UHI anomalies, diurnal temperature variations, and long-term UHI patterns, offering crucial insights for sustainable urban development in rapidly expanding cities like Delhi. The findings reveal an upward trend in UHI, emphasizing the need to integrate UHI effects and WBT considerations into city planning, with a focus on enhancing green infrastructure and mitigating urban heat retention. Future research should leverage advanced modeling techniques and high-resolution spatial and temporal datasets to improve UHI trend predictions, explore interactions with air pollution and climate change, and evaluate their implications for urban heat stress and public health.

Keywords: Urban Heat Island, Wet Bulb Temperature, Thermal Heat Stress, Diurnal Temperature Variation, UHI Anomaly Trend.

Hemavarshini B. R.
CARE - 0035

Agricultural Drought Vulnerability Assesment for Oddanchatram Taluk, Tamil Nadu for the Years 2000, 2008, 2016 and 2022 Using Geospatial Techniques

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ABSTRACT

Vulnerability of agriculture to drought happens to be a perennial problem in the semiarid regions as it poses tremendous challenge to the livelihood of the farmers and also to the overall food security. The Oddanchatram taluk in Dindigul district of southern Tamil Nadu is one such a region where agriculture plays a major role in the local economy. However, the area is also periodically suffers from drought owing to insufficient / delayed monsoons causing number of socioeconomic problems. Hence, an attempt has been made in the present study to assess the agricultural drought vulnerability of Oddanchatram taluk for the years 2000, 2008, 2016 and 2022 using Geospatial techniques. The agricultural drought vulnerability in the study area was assessed using the spatio-temporal dynamics of the following indices like Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST), Soil Moisture Index (SMI), Standardized Precipitation Index (SPI), Groundwater Level (GWL), Temperature Condition Index (TCI), Vegetation Condition Index (VCI) and Vegetation Health Index (VHI). All the indices were determined from the analyses of LANDSAT images but for Standardized Precipitation Index (SPI) and Groundwater Level (GWL) that were obtained from Indian Meteorological Department (IMD) and Indian Water Research Information System (IWRIS) respectively.

From the data integration of the above indices in GIS, an Integrated Drought Severity Index (IDSI) map for the study area with the following classes viz. a. extreme drought, b. severe drought, c. moderate drought, d. mild drought and e. no drought was prepared for the years under consideration. The same has indicated that the agricultural drought vulnerability was severe in the study area for the years 2008 and 2022 as the combined area falling under extreme and severe drought conditions classes found to cover an area of 45.47% and 38.04% respectively. Thus, the present study has indicated that geospatial techniques can play an effective role in the agricultural drought vulnerability assessment and management.

Keywords: Agricultural Drought, Oddanchatram Taluk, Drought Indices, Remote.

Hindhiya Shabu
CARE - 0109

Multidecadal Variability in ENSO-Indian Monsoon Coupling in Last Millennium Coupled Model Simulations and Paleoclimate Data Assimilation Products

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ABSTRACT

The El Niño-Southern Oscillation (ENSO) is a key driver of interannual variability in the Indian Summer Monsoon (ISM). However, this relationship exhibits significant multidecadal variability, with a noticeable weakening trend in recent decades. Understanding the potential drivers of these multidecadal changes in the ENSO-ISM correlation is crucial. However, the relatively short duration of instrumental records limits our ability to fully capture long-term variability and potential shifts in ENSO-ISM dynamics. To overcome this limitation, we analyze multiple present- day and paleoclimate model simulations, along with paleoclimate reconstructions, to extend our understanding beyond the observational period.

An analysis of the 31-year running correlation between ENSO and the Indian Summer Monsoon (ISM) using the Community Earth System Model Last Millennium Ensemble (CESM-LME) reveals that the correlation is significant during 55% of the last millennium, while it remains insignificant during the remaining 45% of the period. This indicates that the ENSO-ISM relationship is not stationary over time and may be influenced by various external or internal climatic factors. To better understand these variations, we analyze the role of external forcings and internal climate dynamics in modulating ISM-ENSO correlations over the past millennium. For this, we analyzed full forcing and individual external forcing ensemble members in CESM-LME (volcanic, solar, orbital, LULC, and GHG). Nevertheless, we observed no consistent epoch in which all forcing ensembles coincided with any external forcing in triggering correlation breakdown, indicating a more stochastic than deterministic effect of external forcings on ISM- ENSO coupling. P-values were used to define two epochs, referred to as significant and insignificant years. To identify the internal dynamic factors driving the ENSO-ISM relationship, a composite pattern analysis of various climate variables across these epochs is currently underway.

Keywords: ENSO-ISM Correlation, Paleoclimate Models, Paleoclimate Reconstructions, CESM-LME.

Jayasankar C. B.
CARE - 0142

Diurnal Temperature Range Projections for India: A Regional Climate Modeling Approach

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ABSTRACT

This study examines the projected changes in the Diurnal Temperature Range (DTR) over India and to explain its considerable spatial heterogeneity from a 20-km resolution coupled ocean-atmosphere regional climate model (RSM-ROMS) integration. The RSM-ROMS is driven at the lateral boundaries by the Community Climate System Model version 4 (CCSM4) model. Observations reveal spatial heterogeneity in DTR trends with significant declining trends at many grid points interspersed with areas of either increasing or insignificant trends of DTR during each of the four seasons. The present-day simulations from RSM-ROMS show reasonable skill in simulating the daily maximum (T_{max}) and minimum (T_{min}) temperature over India.

Results show that there is a significant decrease in DTR across various regions and seasons in the projected mid-21st century (2041-2060) climate under the RCP 8.5 scenario. The future reduction in DTR over Region-1 (over Bihar and the eastern regions of Uttar Pradesh) during December-February (-0.86℃), and over Region-3 (over the rain shadow regions of Peninsular India) during June-September (-0.49℃) is attributed to an increased cloud cover at the time of diurnal maximum in the future, leading to a decrease in incoming shortwave radiation at the surface. These changes are also coincident with a reduction in the surface sensible heat flux and planetary boundary layer height, coupled with an increase in surface latent heat flux. As a result, the Tmax warming rate is less compared to the Tmin warming, which leads to a reduction of the DTR. On the other hand, Region-2 (over Rajasthan) exhibits insignificant DTR changes in the mid-21st century climate.

Keywords: Diurnal Temperature Range, Dynamical Downscaling, Regional Climate Model, Climate Change.

Impact of Volcanic Aerosols on the Indian Summer Monsoon: Insights From the Past Millenium

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ABSTRACT

Volcanic eruptions have been among the most significant natural drivers of climate variability over the past millennium. These eruptions inject aerosols into the lower stratosphere, reducing the amount of solar radiation that reaching the Earth's surface and weakens the global hydrological cycle. These large-scale natural occurrences provide excellent opportunities for testing how climate models respond to external forces. This study investigates the impact of major eruptions (850–1849 CE) on the Indian Summer Monsoon (ISM) using the Community Earth System Model Last Millennium Ensembles (CESM-LME). Eruptions are categorized as Tropical, Northern, or Southern based on their volcanic forcing in CESM-LME.

Our findings reveal a substantial decline in ISM precipitation during the eruption year (Year 0), with drier conditions persisting for up to two years post-eruption. The probability of El Niño events increases in the year following an eruption (Year +1), further exacerbating ISM drought conditions. The initial drying is primarily attributed to enhanced atmospheric stability and weakened monsoon circulation, while post-eruption drought conditions are driven by both direct volcanic forcing and volcanic-induced El Niño dynamics. The response is strongest for Tropical eruptions, followed by Northern and Southern eruptions. These results provide crucial insights into the complex relationships between volcanic activity, ENSO dynamics and monsoonal variability, with implications for future climate projections.

Keywords: Past Millenium, Volcanic Aerosols, Regional Hydrological Cycles.

Dispersion Characteristics of Anisotropically Scaled Moist Equatorial Waves

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ABSTRACT

A theoretical framework is developed to address the dispersion characteristics of convectively driven moisture modes within the equatorial waveguide through anisotropic space/time scalings. The forced shallow water model is coupled with an advection-condensation model, in which moisture is explicitly defined as a prognostic variable used to deduce the multi-scale convective dynamics. Nonlinearity is intrinsic to the model and is due to advective transport and diabatic interactions. However, in the linear regime, the results explain the modification of equatorial waves due to anisotropic scaling and resonant interactions between them.

It is observed that, for selected values of the anisotropy parameter, the dispersion spectrum experiences intersections of moist modes (overlapping of the dispersion curves), and these intersecting curves indicate chains of interacting waves. Due to this resonance mechanism, the speed of the large-scale equatorial Kelvin wave is reduced through dispersion, and energy is localized at planetary-scale wavenumbers. Additionally, there is substantial energy exchange at specific zonal wavenumbers with other large- scale equatorial waves, such as mixed Rossby-gravity and planetary-scale Rossby waves.

Keywords: Equatorial Waves, Moisture Dynamics, Anisotropic Scaling, Multi-Scale Convective Dynamics.

Inclusion of Bioethics in General Education

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ABSTRACT

Climate change is not only an environmental and scientific challenge but also an ethical issue requiring a multidisciplinary approach. Ethical considerations such as justice, equity, responsibility, and sustainability are central to addressing climate adaptation effectively. This paper argues for the integration of bioethics into education as a foundational component of climate adaptation policy frameworks. By embedding bioethical principles in curricula, students and future policymakers can develop a deeper understanding of the ethical dimensions of climate adaptation, including resource allocation, intergenerational equity, and the protection of vulnerable communities. A bioethics-integrated education system promotes critical thinking, ethical decision- making, and environmental stewardship. It enables individuals to analyze the ethical consequences of climate policy, ensuring that adaption measures are both scientifically sound and socially just. Furthermore, introducing bioethics into education encourages multidisciplinary collaboration, bridging the divide between science, policy, and human rights.

This research investigates policy proposals for incorporating bioethics into climate education at many academic levels. It emphasizes the need of educational institutions in creating ethical climate leaders and ensuring that adaption strategies are consistent with ideals of fairness, inclusion, and sustainability. The debate stresses the importance of capacity-building initiatives, regulatory promotions, and public engagement tactics in developing a generation of morally informed decision-makers. Bioethics may be used as a framework to establish climate policies that promote social justice while tackling the pressing concerns posed by climate change.

Keywords: Bioethics in Education, Climate Adaptation Policy, Environmental Ethics, Sustainability and Justice, Interdisciplinary Climate Governance.

Strengthening Trade Winds in a Changing Climate

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ABSTRACT

Trade winds over the tropical oceans are the most consistent wind fields, especially over the Pacific. They are governed by the energy exchange rate between the surface and the atmosphere. The strong convergent zones of trade winds around the equator develop vertical motions, giving rise to large- scale Hadley and Walker circulations, which influence the global climate. A quantitative analysis of changes in trade winds and these circulations is necessary to understand the changes in global weather patterns. This study quantitatively analyses how trade winds change over the tropical oceans, particularly for the Pacific and the Indian Ocean, for the period 1940-2023 using ERA5 reanalysis datasets. Here, we define trade wind zones for each ocean basin for each season based on the consistency of wind speed and direction throughout the period. Analysis is carried out to know how they vary and the causes for the variability. We also study the variability of high-pressure zones and the meridional circulation which leads to the trade wind changes.

The results reveal that the trade wind speed is increasing irrespective of the season for all ocean basins. The rate of increase differs by season and ocean. Except for June to August, Pacific Ocean trade winds show a 10-12% increase in speed. The Indian Ocean southerly trade winds for December to May show a 0.8 m/s increase which is 13-15%. Analysis of sea level pressure (SLP) of the key area influencing the Pacific trade winds shows an increasing trend. The SLP shows an increasing trend in the near poleward latitudes of climatological high-pressure belts which can be related to the widening of the Hadley cell reported in earlier studies. Further analysis is carried out to find the role of internal variability of the Pacific Ocean on trade winds.

Keywords: Trade Wind, Air-Sea Interaction, Tropical Ocean, Climate Change, Hadley Circulation.

Kavya Johny
CARE - 0069

When AI Meets Meteorology: Modelling the 2018 Extreme Kerala Flood

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ABSTRACT

Artificial Intelligence (AI) can outperform in various fields of research due to their diligence, speed, and accuracy in predictions. The frequency of extreme weather events is increasing in the backdrop of climate change, and prediction of such events with sufficient lead time is essential for early warning and preparedness. Relying on a single model simulation to predict such extreme events may lead to inaccuracies in intensity and spatio-temporal evolution. This study aims to evaluate the accuracy of rainfall forecasts using AI-integrated weather research and forecasting (WRF) model ensemble outputs for real time prediction. In the south Indian State of Kerala, an extended period of extremely heavy rainfall occurred during 14^{th} – 16^{th} August 2018 due to a monsoon depression in the head Bay of Bengal, resulting in mega flooding accompanied by unprecedented loss of human life and damage to infrastructure. The skill of the WRF model in predicting such extreme rainfall events with sufficient lead time is assessed through a series of simulations.

The study identifies the right combination of parameterization schemes that best reproduces the atmospheric processes during the event. Model predictability can be significantly improved by assimilating observations, and this study investigates the efficiency of assimilation in WRF (WRF-DA) in terms of spatial distribution, intensity, and lead-time. This is achieved from multiple forecast outputs generated by varying the initial conditions. The assimilated forecasts are giving better performance than normal WRF forecasts with an increased correlation of 0.3. These outputs are fed into an AI model of Long Short Term Memory (LSTM) to achieve optimal forecast performance in terms of spatio-temporal distribution and intensity. The proposed novel AI model (WRFDA-LSTM) maximizes the prediction accuracy with 0.66 spatial correlation. Several other performance metrics are calculated for each model, and the results indicate that the WRFDA-LSTM model performs well. The overarching goal is to demonstrate the advantage of combining AI with physical models to enhance real-time forecasting capabilities with potential application in early warning and disaster preparedness.

Keywords: Modelling, Weather Research and Forecasting, Artificial Intelligence, Data Assimilation, Extreme Weather Forecasts.

Krishna Jayamohan
CARE - 0041

Deep Learning-Based Prediction Model and Early Warning for Rainfall-Induced Landslides in Idukki, Kerala

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ABSTRACT

Landslides pose a significant threat to the Idukki District of Kerala, India, aggravated by steep terrain, heavy monsoon rainfall, and fragile soil, leading to substantial loss of life and property. This study addresses the critical need for accurate prediction and early warning systems for rainfall-induced landslides in Idukki. The research uses a Long Short-Term Memory (LSTM) deep learning model to improve forecasting accuracy, integrating historical rainfall data (2018-2019) with geospatial variables such as slope, elevation, geology, geomorphology, and land use. The methodology involves collecting data from sources like the Kerala State Disaster Management Authority, Geological Survey of India, and CHRS Data Portal, processed via ArcGIS and Python. The LSTM model, featuring two layers (100 and 50 units), was trained on an 80-20 split dataset, capturing temporal rainfall patterns effectively due to its ability to retain long-term dependencies.

Performance evaluation yielded a test accuracy of 97.1%, with precision, recall, and F1-scores of 96.3%, and a root mean squared error of 1.68 mm, outperforming traditional methods like Logistic Regression and Decision Trees. Results identified key landslide triggers: a daily rainfall intensity of 12.86 mm/day and a 7-day antecedent rainfall of 130.56 mm. The model was integrated into a real-time early warning system, classifying risks as High ($\geq$0.75 probability), Moderate (0.50–0.74), or Low (<0.50), enhancing disaster preparedness. While rainfall intensity showed moderate predictive power (AUC 0.67), the comprehensive data integration reduced false negatives, addressing limitations of static systems. In conclusion, this LSTM-based approach offers a reliable, adaptable framework for landslide prediction in Idukki, surpassing traditional models and supporting timely interventions amid climate- driven rainfall intensification. Future improvements could add soil conditions, human activity data, or hybrid models to boost accuracy, aiding disaster management in landslide-prone areas.

Keywords: Landslide Prediction, Long Short-Term Memory, Rainfall, Early Warning, Idukki

Krishna Kumar E. K.
CARE - 0129

Contrasting Regional Responses of Indian Summer Monsoon Rainfall to Exhausted Spring and Concurrently Emerging Summer El Niño Events

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ABSTRACT

The inverse relationship between the warm phase of the El Niño Southern Oscillation (ENSO) and the Indian Summer Monsoon Rainfall (ISMR) is well established. Yet, some El Niño events that occur in the early months of the year (boreal spring) transform into a neutral phase before the start of summer, whereas others begin in the boreal summer and persist in a positive phase throughout the summer monsoon season. This study investigates the distinct influences of an exhausted spring El Niño (springtime) and emerging summer El Niño (summertime) on the regional variability of ISMR. The two ENSO categories were formulated based on the time of occurrence of positive SST anomalies over the Niño-3.4 region in the Pacific. The ISMR's dynamical and thermodynamical responses to such events were investigated using standard metrics such as the Walker and Hadley circulations, vertically integrated moisture flux convergence (VIMFC), wind shear, and upper atmospheric circulation.

The monsoon circulation features are remarkably different in response to the exhausted spring El Niño and emerging summer El Niño phases, which distinctly dictate regional rainfall variability. The dynamic and thermodynamic responses reveal that exhausted spring El Niño events favor excess monsoon rainfall over eastern peninsular India and deficit rainfall over the core monsoon regions of central India. In contrast, emerging summer El Niño events negatively impact the seasonal rainfall over the country, except for a few regions along the west coast and northeast India.

Keywords: Exhausted Spring El Niño, Emerging Summer El Niño, Indian Summer Monsoon, Hadley and Walker Circulation, Tropical Easterly Jet, Vertical Integrated Moisture Flux Convergence.

Lakshman Kesireddy
CARE - 0031

High-Resolution Analysis of Severe Heat Wave Dynamics and Thermal Discomfort Across India

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ABSTRACT

The study explores variability and dynamical characteristics of heatwaves during March–June for 1990–2020 over India. Normalized Tmax anomaly is used to identify different heatwave spells in vulnerable regions of North-central India (NCI) and Southeast coast of India (SECI) using India Meteorological Department (IMD) observations, Indian Monsoon Data Assimilation and Analysis (IMDAA), and ECMWF Reanalysis v5 (ERA5).

Results highlight that the primary heatwave periods for NCI (10 April to 20 June) and SECI region (1 May to 10 June) are well captured by IMDAA, unlike ERA5. The middle to upper-level anticyclone over NCI is stronger than SECI during heatwaves. Heat advection with stronger 850-hPa north-westerlies (~10 ms^{-1}) abates sea breeze in the coastal region, aiding longer heatwaves in the SECI region. Ascending motion induced by surface heating is confined to the lower levels due to the subsidence by the upper-level anomalous anticyclone, stagnating higher temperatures in the lower atmosphere, depicting a heat dome. The surface temperatures are slightly higher in NCI (31°C–39°C) than in SECI (30°C–37°C). However, the double moist heat dome in SECI has witnessed higher heat stress conditions than NCI. Higher relative humidity in the SECI region is contributed by maritime winds from the Bay of Bengal and Arabian Sea, soil moisture, and so forth. The study highlights the value of atmospheric moisture in differentiating the study regions for heat stress conditions.

Keywords: Heatwave, Heat Dome, Anti-cyclone, Thermal Discomfort.

Lincy Davis
CARE - 0090

Verification of Medium Range Weather Forecast and its Role in Agromet Advisory Services

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ABSTRACT

The study was conducted by AMFU, Thrissur, focused on verifying medium-range (5 days) weather forecasts (MRWF) against observed weather data from the observatory situated at College of Agriculture, KAU, Vellanikkara.

Results showed high reliability for maximum and minimum temperature forecast, with annual usability of 86.61% and 86.06%, respectively. Maximum temperature was most reliable in winter (96.67%), while minimum temperature was most reliable during the South West Monsoon (SWM) season (94.26%). Relative humidity had high annual usability (94.81%), with the highest values during SWM (100%) and the lowest in winter (85%). Minimum relative humidity had a significant drop during SWM (46.”2%). Wind speed showed perfect reliability with 100% usability across all seasons. Rainfall had notable seasonal variation, with the summer season contributing the highest usable fraction (40.22%) and winter the lowest (23.91%), with SWM having high non-usable fractions (75.21%). These analyses help integrate seasonal meteorological variability into farming practices, offering vital insights for improved agricultural productivity and resilience. Weather-based advisories are provided twice a week to farmers in 690 districts via Agro Meteorological Field Units (AMFUs) across130 agro-climatic zones. These advisories were prepared in both English and Malayalam, were delivered through various platforms like websites, emails, SMS, WhatsApp, Facebook, YouTube and apps. The Agromet Advisory Service (AAS) supports farmers by integrating climate/weather data with agomet advisories to help them make informed decisions.

Keywords: Medium-Range Weather Forecasts (MRWF), Weather Forecast Verification, Gramin Krishi Mausam Sewa (GKMS), Agromet Advisory Service.

Malavika A. R.
CARE - 0030

Comparative Analysis and Statistical Evidence of Deep Ocean Warming Trend in the Arabian Sea and Bay of Bengal

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ABSTRACT

Oceans are huge reservoirs of heat due to their high heat capacity and vastness and hence play a crucial role in maintaining climate and life on Earth. However, gradual changes in the ocean state can have a significant impact on the Earth's climate. The ocean temperature during the second half of the 20th century has shown a steadily increasing trend as an impact of global warming. This study conducts a comparative analysis of surface and subsurface ocean temperature in the Arabian Sea (AS) and Bay of Bengal (BoB) basins of the Indian Ocean (IO) to estimate the varying impact of warming in the deeper layers of IO. The monthly mean of the Sea Surface Temperature (SST) and the Subsurface Temperature (ST) data for the depths of 25m, 55m, 98m, 135m, 235m, 540m and 967m are spatially averaged over the two basins for the period 1950 to 2024 and is then subjected to a statistical Ensemble Empirical Mode Decomposition (EEMD) analysis.

The temperature signal is decomposed into components called Intrinsic Mode Functions (IMFs) along with a residual part. Each mode function consists of information regarding how the frequency of the original signal varies with time. The IMFs represent the temperature fluctuations resulting from inter-annual oscillations such as El-Nino Southern Oscillation (ENSO), Quasi-Biennial Oscillations (QBO) and Pacific Decadal Oscillations (PDO). The contribution of each inter-annual forcing to the total variability and its depth of influence is quantified. The residual part of the signal which represents the trend is free of high-frequency oscillations and is therefore more realistic. Analytical results showed the presence of ENSO signals even up to 1000m. EEMD analysis at 8 different depths within the 1000m water column resolved contributions from other oscillations such as seasonal, QBO, and PDO. IMFs corresponding to seasonal and QBO oscillations dominated in contribution to the total variability. The temperature trend has a significant warming phase indicating the penetration of global warming signals, except for an anomaly at 98m, 135m and 235m. Interestingly, the warming trend is higher for BoB up to 100 meters, but as depth increases the AS warming trend is dominating.

Keywords: Sub-surface Temperature, EEMD, Global Warming, Indian Ocean.

Building Climate Resilient Cities; The Role of Eco- Innovation and Sustainable Infrastructure

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ABSTRACT

Cities' growing susceptibility to the effects of climate change makes climate-resilient urban planning imperative, with eco-innovation and sustainable infrastructure serving as key components. This study tackles the crucial issue of how cities may combine sustainable infrastructure with eco-innovative solutions to reduce and adapt to climate change while maintaining long-term resilience. The background study draws attention to the increasing occurrence of extreme weather events, the growing urban population, and the unsustainable patterns of development that increase the hazards associated with climate change. In order to analyze current legal frameworks, regulations, and case studies from different cities throughout the world that have effectively implemented eco-innovation strategies and sustainable infrastructure, the study uses a doctrinal research methodology.

By using this method, the study highlights the significance of public-private partnerships, the role of governance, and important legal and regulatory issues in promoting climate resilience. The findings demonstrate that cities are better positioned to lower climate risks, increase resource efficiency, and improve quality of life when they place a high priority on green infrastructure, renewable energy integration, and circular economy models. The study also emphasizes how crucial it is to match sustainable development objectives (SDGs) with urban planning in order to establish an all- encompassing, flexible urban framework. The study concludes that in order to create communities that can weather future climate problems, a comprehensive strategy combining technical innovation, legislative changes, and community involvement is required. In order to make eco-innovation and sustainable infrastructure a key component of urban development policies and help create more resilient, sustainable, and livable cities, it urges cooperation from all sectors.

Keywords: Climate Resilience, Eco-Innovation, Sustainable Infrastructure, Urban Planning.

Cloudsense:
A Model for Cloud Type Identification Using Machine Learning from Radar Data

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ABSTRACT

The knowledge of type of precipitating cloud is crucial for radar based quantitative estimates of precipitation. We propose a novel model called CloudSense which uses machine learning to accurately identify the type of precipitating clouds over the complex terrain locations in the Western Ghats (WG) of India. CloudSense uses vertical reflectivity profiles collected during July-August 2018 from an X-band radar to classify clouds into four categories namely stratiform, mixed stratiform-convective, convective and shallow clouds. The machine learning (ML) model used in CloudSense was trained using a dataset balanced by Synthetic Minority Oversampling Technique (SMOTE), with features selected based on physical characteristics relevant to different cloud types.

Among various ML models evaluated Light Gradient Boosting Machine (LightGBM) demonstrate superior performance in classifying cloud types with a BAC (Balanced Accuracy) of 0.79 and F1- Score of 0.8. CloudSense generated results are also compared against conventional radar algorithms and we find that CloudSense performs better than radar algorithms. For 200 samples tested, the radar algorithm achieved a BAC of 0.69 and F1-Score of 0.68, whereas CloudSense achieved a BAC of
0.8 and F1-Score of 0.79. Our results show that ML based approach can provide more accurate cloud detection and classification which would be useful to improve precipitation estimates over the complex terrain of the WG.

Keywords: Machine Learning, Precipitating Clouds, Doppler Weather Radar, Western Ghats, LightGBM.

Melvin Manoj Abraham
CARE - 0025

Socio-Economic Vulnerability and Disaster Resilience: Assessing Coastal Households in Veliyancode Panchayat, Kerala

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ABSTRACT

Coastal communities are increasingly vulnerable to natural disasters such as coastal erosion, cyclonic storms, tsunamis, and flooding. This study assesses the economic vulnerability and disaster preparedness of deprived coastal households in Veliyancode Panchayat, Malappuram district, Kerala. Using a vulnerability assessment framework, data was collected through field interactions across 18 wards (approximately 1,700 households) to evaluate community awareness, evacuation preparedness, and government support. To address these challenges, the study adopts a top-down approach, linking socioeconomic vulnerability assessments from the district level to local self-governance and the community.

The findings highlight critical gaps, with 37% of respondents unaware of evacuation sites, 80.1% lacking knowledge of swell surges, and 83.6% never participating in mock drills. Highly vulnerable zones were identified in Wards 1, 2, 15, 17, and 18, where exposure to coastal hazards is severe. While 72.5% of residents received disaster warnings, 27.5% did not, underscoring the need for improved communication systems. This research underscores the importance of targeted adaptation and mitigation strategies that improve resilience in coastal communities. Strengthening disaster preparedness through training programs, regular mock drills, and increased community awareness can significantly reduce disaster risks. The insights from this research contribute to policy recommendations that enhance disaster risk reduction efforts, ensuring that vulnerable coastal populations are better equipped to face future hazards.

Keywords: Climate Change, Coastal Disasters, Disaster Risk Reduction, Resilience.

Assessing Coastal Vulnerability and Enhancing Disaster Resilience: A Socio-economic Study in Eriyad Grama Panchayat, Kerala

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ABSTRACT

Climate change is intensifying the frequency and intensity of disasters worldwide. The coastal communities in Kerala are vulnerable to disasters in various physical, social, political and economic contexts and are exposed to the losses and damage caused by coastal disasters like Tsunami, Cyclones, Storm surges, Swell waves, Coastal flooding etc. Hence, to comprehensively assess the coastal vulnerability and its susceptibility to Tsunami occurrences and related disasters, a systematic and multidisciplinary socioeconomic study approach was adopted by us at the Eriyad Grama Panchayat in Thrissur district. Structured and semi-structured questionnaires incorporating open-ended questions were prepared and a random sampling method was used to collect the data.

The most vulnerable wards, frequently exposed to disasters such as Tsunami(2004), Cyclone Ockhi (2017) and the floods (2018 and 2019) have developed significant resilience due to their repeated experiences. Their proximity to the sea and susceptibility to tidal variations often result in flood-like conditions, further emphasizing the need for continued preparedness. The study found that 94.3 % of the surveyed population is aware of various types of natural disasters and 72.8% of them are receiving early warnings on time. Whilst 79% of the people have not received any training on how to respond to alert warmings or other extreme events, a significant minority of 46.4% also stated they had not received classes on coastal disasters. Our study highlighted the need for efficient community-based disaster management strategies and continuous training programs. Enhancing disaster resilience through disaster risk reduction efforts are crucial for saving lives, protecting property and promoting sustainable development within the coastal community.

Keywords: Climate Change, Coastal Disasters, Disaster Risk Reduction, Resilience.

Muhammed Althaf P. N.
CARE - 0114

Changing Patterns of Monsoonal Rainfall and Climate Variability over North-West India: A Century-Long Perspective on Rainfall Trends, Extremes and Circulation Dynamics

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ABSTRACT

North-West India (NWI) has traditionally received lower monsoonal rainfall compared to other regions of India. However, a century-long (1901–2022) analysis of Indian Summer Monsoon Rainfall (ISMR), based on long-term observational datasets, reveals a strengthening trend in precipitation over this region, particularly in recent decades. A normalized time-series analysis indicates a weak but positive rainfall trend over the entire study period (long-term trend: 1901–2022), which has significantly intensified in the recent period (1999–2022). To further understand these changes, we analysed categorical rainfall events using India Meteorological Department (IMD) classifications.

Our results indicate an overall increase in wet days in the recent period, with medium-intensity rainfall events contributing the most to seasonal rainfall (~65%), followed by high-intensity (~23%) and low-intensity (~12%) rainfall events. In terms of wet days, low-intensity rainfall dominates (~60%), followed by medium-intensity (~37%) and high-intensity (~3%) rainfall events. A notable increase in the contribution of medium-intensity and high-intensity rainfall events to both seasonal rainfall and wet days in the recent period suggests a shift toward more intense precipitation patterns, impacting the region's hydrology and climate dynamics. Additionally, large-scale circulation patterns support this trend, indicating strengthened moisture convergence over NWI in the recent period compared to the earlier period, further reinforcing the observed increase in rainfall intensity and frequency.

Keywords: North-west India, Indian Summer Monsoon Rainfall, Wet Days.

Investigation on Thermodynamic Parameters Associated with Thunderstorm Activity in Kerala, India

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ABSTRACT

Thunderstorms are hazardous weather events increasingly recognized as sensitive to ongoing climate change. This study examines the thermodynamic parameters associated with the thunderstorm activity in three regions of Kerala, India-Thiruvananthapuram Airport, Cochin International Airport Limited (CIAL), and Kannur-during the pre-monsoon seasons from 2013 to 2023. Thunderstorm days are identified from records provided by the Indian Meteorological Department (IMD). The analysis reveals that the highest frequency of thunderstorms occurs predominantly in the afternoon hours (15:00–18:00 IST) across all regions. However, a distinct peak in nocturnal thunderstorms is observed during the hours of 00:00-03:00 IST at Thiruvananthapuram Airport and CIAL, and between 03:00-06:00 IST at Kannur.

This irregular shift in thunderstorm timing suggests a possible disruption of the conventional diurnal thunderstorm cycle, potentially driven by changing thermodynamic conditions. To understand the underlying mechanisms, hourly ERA5 reanalysis data from both evening and late-night thunderstorm days were analyzed. Key thermodynamic parameters, including Convective Available Potential Energy (CAPE), Convective Inhibition (CIN), Cloud Base Height (CBH), K-Index (KI), and Total Totals Index (TTI), were examined within a 24-hour window centred around peak thunderstorm occurrence. CAPE shows a pronounced peak approximately 5 to 6 hours before the initiation of thunderstorms, with values exceeding 1200 J/kg during late-night thunderstorm events. Persistent instability, as indicated by KI and TTI, lasts for 4 to 6 hours during nocturnal thunderstorms, which is accompanied by the formation of low-level convective clouds. The longer duration of nocturnal thunderstorms than evening events indicates a potential shift in convective dynamics. Night-time thunderstorms are different in each region, showing they are caused by local weather, not widespread patterns. In contrast study identifies afternoon a thunderstorm day common to three regions, showing that strong updrafts at 500 hPa precede storm initiation. Northeasterly winds at 850 hPa and the rapid depletion of moist static energy between 950 and 600 hPa further enhance instability, contributing to prolonged nocturnal convection. These findings underscore the critical role of thermodynamic processes in influencing thunderstorm activity in Kerala. The study emphasizes the need for continued monitoring and further investigation into the evolving dynamics of extreme weather events in the region.

Keywords: Thunderstorm Activity, CAPE, CIN, Moist Static Energy.

Naveen A. Y.
CARE - 0099

Decoding Landslide Risks: A Unified AHP, GIS, and Rainfall Threshold Approach in Idukki District, Kerala

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ABSTRACT

The Western Ghats, designated a UNESCO World Heritage Site in 2012, are a globally significant ecological hotspot facing rising landslide occurrences due to climate change and developmental pressures. Increasing monsoonal extremes, deforestation, road construction, and unregulated land- use changes have destabilized slopes, intensifying landslides in this fragile mountain system. According to the National Disaster Management Authority (NDMA), the Himalayas, Western Ghats, and Eastern Ghats are India's most landslide-prone regions, with frequent slope failures causing economic losses and fatalities. Among these regions, Idukki district in Kerala is particularly vulnerable due to its steep terrain, intense monsoonal rainfall, and anthropogenic activities. In 2018, 2,219 landslides were recorded in Idukki, accounting for 46.93% of Kerala's total landslides (Kerala State Disaster Management Authority), making it one of the most disaster-prone zones in the Western Ghats.

This study integrates the Analytical Hierarchy Process (AHP) with geospatial techniques to develop a landslide susceptibility map. Ten key landslide conditioning factors—including slope, elevation, geomorphology, lineament density, topographic position index (TPI), land use/land cover (LULC), Normalized Difference Vegetation Index (NDVI), Relative Landslide Index (RLI), rainfall, and proximity to streams-were weighted using AHP modelling. The resultant landslide susceptibility classes stratify the district into five categories: Very Low (0.001%), Low (11.22%), Moderate (87.49%), High (54.73%), and Very High (0.009%) susceptibility zones. Validation using Bhukosh landslide inventory points confirmed the model's accuracy and reliability. A rainfall Intensity-Duration (I-D) threshold analysis was conducted to refine risk assessment by evaluating extreme precipitation events. A region-specific I-D threshold equation was derived from historical landslide-triggering rainfall data and compared with the global I-D threshold (Caine, 1980). The analysis reveals that sensitive zones in the Western Ghats frequently experience rainfall intensities exceeding global thresholds, with the regional threshold offering a more accurate representation of landslide risks. Integrating I-D threshold analysis with AHP-based susceptibility mapping enhances predictive accuracy, supporting early warning systems, sustainable land-use planning, and disaster preparedness in ecologically sensitive regions.

Keywords: Landslide Susceptibility, AHP, GIS, Western Ghats, I-D Threshold, Idukki.

Intensification of Heat Waves in India: Synoptic Conditions and Atmospheric Dynamics

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ABSTRACT

Heat waves have become one of the most intense and devastating meteorological phenomena, causing severe risks to human health, agricultural productivity, and ecosystems due to their rising frequency, prolonged duration, and increasing intensity. In India, these extreme events primarily occur during the pre-monsoon season (March to mid-June), with recent years (2016, 2019, 2022, and 2023) experiencing a marked escalation in their occurrence. This study investigates the evolving dynamics of heat waves and associated synoptic conditions across India, utilizing maximum temperature data from the India Meteorological Department (IMD) and heat wave indices to assess their severity and impacts.

The analysis reveals a significant increase in heatwave frequency and duration, particularly over northern and central India. Warm air advection, coupled with descending air in the sinking branch of the Walker circulation, created a stable and arid atmosphere, promoting heatwave conditions. Additionally, a persistent anticyclonic circulation and its associated high-pressure system facilitated heat-trapping, resulting in prolonged and intensified heat waves. The study also identifies shifts in the position and strength of the subtropical jet stream (STJ) during these years, highlighting its crucial role in the formation and intensification of heat waves.

Keywords: Heatwave, Climate Change, Subtropical Jet Stream, Walker Circulation.

Niranjana Krishna
CARE - 0053

Analyzing the Heat Wave and Its Impact on Heat Stress: A Comparative Study Between Rajasthan and Andhra Pradesh

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ABSTRACT

Global warming and meteorological changes are exacerbating extreme weather occurrences, with India experiencing significant problems from rising heat stress. According to previous studies, the heat waves would become more frequent and alarming from pre-monsoon into monsoon seasons, notably in northwest India and South east coastal regions. Heat stress is one of the extreme weather events becoming a challenging societal problem in the warming environment. Given the size of the population and the range of activities they indulge in, it is essential to comprehend and analyze heat stress in order to protect the health and productivity of individuals across a variety of sectors. An appropriate measure which can be used for assessing thermal stress that humans experience is the Wet Bulb Temperature (WBT) and the Heat Index (HI), which considers a number of meteorological factors like humidity and temperature. This study looks at heat stress dynamics between Rajasthan and Andhra Pradesh utilizing thermal indices, HI and WBT along with other meteorological factors in the pre-monsoon period (March to June) between 1993-2023.This study employed IMD, gridded maximum temperature data to identify heat wave episodes in both states and used ERA5 hourly and ERA5 land data to further understand the moisture parameters like specific humidity and relative humidity in these regions.

The findings show geographical and temporal variations in heat stress patterns, with Rajasthan having earlier and more extreme heat wave occurrences than Andhra Pradesh. Statistical analysis highlights the elevated heat stress conditions during heat wave periods, stressing the importance of humidity in addition to temperature in assessing heat stress.

Keywords: Global Warming, Extreme Weather, Thermal Stress, Wet Bulb Temperature, Heat Index.

Climate Variation Effects on Sound Propagation Loss in South Eastern Arabian Sea

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ABSTRACT

Increasing anthropogenic greenhouse gas (GHG) concentrations cause rise in ocean heat content that leads ocean warming. This has been observed since 1950s, reaching record values in the period 2012–2021. Climate change is fundamentally altering underwater soundscapes through the combined effects of global warming and ocean acidification. Rising ocean temperatures modifiesthe underwater sound speed profile and that alters the propagation paths which in turn causes variation in noise level. Concurrently, ocean acidification which is driven by the absorption of anthropogenic CO_2 reduces the concentration of borate ions which are responsible for absorbing low-frequency sound waves (<1 kHz). As seawater pH declines, sound absorption diminishes, allowing the noise to travel farther and persist for extended time period.

It has been observed that increased shipping has caused an increase in the ambient noise levels in the ocean and lower attenuations caused by ocean acidification could magnify this increase in noise levels. These changes result in increased background noise levels, with significant ecological, industrial, and military implications. The primary acoustic system used in sea 'SONAR', also affected by these factors and performance is affected. Implementing underwater noise observation networks can facilitate the continuous soundscape monitoring which is critical for predictive ocean acoustic modelling, enabling the adaptive mitigation strategies and monitoring its ecological impacts. This paper focuses on these climate-driven changes in decadal propagation loss variation in the South- Eastern Arabian Sea (SEAS), which is known for its highly variable climatic conditions.

Keywords: Climate Change, SEAS, SONAR, Propagation Loss.

Wind-Precipitation Regimes and Monsoon Intraseasonal Variability: New Insights from the South-West Coast of India

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ABSTRACT

This study examines the non-linearity between wind and precipitation over the southwest coast of India during the Indian summer monsoon using K-means clustering. The Monsoon Low-Level Jet core speed from 205 MHz wind profiler radar in Cochin University of Science And Technology, Cochin and IMD gridded rainfall data were used to identify five distinct wind-precipitation regimes. Two clusters correspond to low-wind regimes, while three fall under high-wind conditions, influenced by different modes of monsoon intraseasonal oscillation (MISO).

The low-wind clusters indicate monsoon breaks over central India, while the high-wind clusters align with MISO-driven variability, including extreme precipitation events associated with northwestward propagating monsoon depressions. Lagrangian back-trajectory analysis reveals that dry air intrusion into the mid-troposphere suppresses rainfall. Conversely, enhanced boundary layer convergence facilitates moisture ascent to 500 hPa, triggering heavy rainfall. These findings highlight key drivers of monsoon variability and provide insights into the complex wind-precipitation relationship over the region.

Keywords: Indian Summer Monsoon, Intraseasonal Oscillations, Wind-Precipitation Relation, K-Means Clustering.

Prasanth Pillai
CARE - 0144

Efficiency of Climate Forecast System CFSv2 to Predict the Regional Scale Drought Events Over India

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ABSTRACT

The present study assesses the ability of Monsoon Mission CFSv2-T382 to simulate the short-term drought during the Indian Summer Monsoon (June to September). The rainfall-based standardized precipitation index (SPI) averaged over the Indian land region showed significant skills for the 1981–2017 hindcast period for both the ICs Category-wise forecasts indicate that even with strong rainfall bias and moderate false alarm ratio, model hindcasts have a better detection ratio, hit rate, etc., demonstrating the model's usefulness for predicting the all-India drought.

The observed SPI over the entire India during the month of June has a strong positive (negative) relationship with soil moisture (surface temperature) over India, along with warm (cold) SST anomalies in the northern Indian Ocean (north tropical Atlantic Ocean). The SST anomalies associated with El Nino Southern Oscillation (ENSO) dominate the drought towards the end of the monsoon season. However, SPI simulated by model hindcasts has a stronger relationship with ENSO throughout the season. The homogenous region-wise skill analysis and teleconnections of SPI explain its scattered skill over Indian land regions. The observed regional surface temperature and soil moisture have a strong 1–2-month lead relationship with SPI in all homogenous regions, and forcing from ENSO is evident for WCI and SPInd only. The model overestimates the simultaneous ENSO relationships for all the homogenous regions, while the lead role of moisture, surface temperature, and north tropical Atlantic SST is under-predicted. WCI and SPInd regions have a moderate lead relationship with soil moisture and surface temperature along with ENSO teleconnection, resulting in improved skill compared to other subdivisions of India. The study shows that further improvement of the regional scale skill of CFSv2 for capturing SPI is possible mainly with the regional scale improvement of land surface processes and its lead teleconnection with SPI in the model.

Keywords: Meteorological Drought, SPI, Seasonal Prediction, ENSO, Soil Moisture.

Harnessing Wind Energy during the Monsoon Season: Opportunities and Challenges for India

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ABSTRACT

India is increasingly turning to renewable energy sources to meet its growing electricity demand and mitigate the impacts of climate change. Among the renewable options, wind energy holds significant promise, particularly in the coastal regions of the country. The monsoon season, characterized by variable wind patterns and heightened wind speeds, presents both opportunities and challenges for harnessing wind energy. This study examines the potential of optimizing wind energy generation during the monsoon months in India by analyzing various weather models that predict wind patterns, intensity, and seasonal variations. Utilizing weather models, from various global circulation models (GCMs) and Regional model (WRF) this study investigates how monsoon winds can be better understood and integrated into wind energy systems.

The analysis reveals that the state of TamilNadu experience high wind speeds during the monsoon (JJAS), offering an opportunity to significantly enhance energy production. However, challenges such as gusty winds, seasonal variations, and infrastructure wear due to heavy rainfall and storms can affect wind turbine efficiency. Additionally, policy frameworks and government initiatives that encourage the integration of wind energy systems capable of handling monsoon-related challenges are discussed. By combining weather modeling insights with technological and policy innovations, the paper proposes strategies for harnessing wind energy efficiently during the monsoon season, contributing to India's transition to a sustainable energy future.

Rapid Intensification of Tropical Cyclone Over North Indian Ocean

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ABSTRACT

Rapid Intensification (RI) of Tropical Cyclones (TCs) within the North Indian Ocean (NIO) basin is still a less understood process. Statistical analysis conducted on a dataset comprising 112 tropical cyclones reveals capturing patterns: while 39.28% of tropical cyclones experienced RI in the Bay of Bengal (BOB), a slightly higher proportion of 40.81% underwent RI in the Arabian Sea (AS). Despite the Bay of Bengal's (BOB) prominence in total TC occurrences, the Arabian Sea emerges as more prone to rapid intensification evets. It holds across different Tropical cyclone categories including Severe Cyclonic Storm (SCS), Very Severe Cyclonic Storm (VSCS), Extremely Severe Cyclonic Storm (ESCS) and Super Cyclonic Storm (SuCS) over both basins. For this case study, we have done an effort to comprehend and identify key synoptic condition, prevail before and during RI TCs to understand its physical mechanisms. A composite Analysis technique, examining the atmospheric condition 24 hours prior to RI onset and Non-RI events at 6 hour intervals. RI onset is defined as instances where the change in maximum sustained wind speed (Δvmax) equals or exceeds 30 knots (Δvmax ≥30), while NRI onset corresponds to the maximum change in intensity observed.

From the composite analysis, it is found that RI TCs have developed over higher SST than NRI. Additionally, identified several key atmospheric parameters associated with RI events, including changes in geopotential height, relative humidity, relative vorticity, vertical wind shear and zonal wind patterns. It exhibits the distinct signatures before and during RI, providing valuable insights into the synoptic conditions favorable to rapid intensification. For evaluating the statistical significance of findings, conducted t-test to compare various parameters between Rapid Intensification (RI) and Non Rapid Intensification (NRI) events. This statistical approach enabled to determine the significance of difference observed in the atmospheric variables between RI and NRI events.

Keywords: Rapid Intensification, Tropical Cyclone, North Indian Ocean.

Riya K. R.
CARE - 0103

Analysing Climate Change Vulnerability and Adaptation Strategies in Kerala

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ABSTRACT

Climate change poses a significant challenge to ecosystems, economies, and communities worldwide, necessitating regional vulnerability assessments to inform targeted adaptation and mitigation strategies. This study evaluates the climate vulnerability of Kerala's 14 districts using the Intergovernmental Panel on Climate Change (IPCC) framework, which incorporates exposure, sensitivity, and adaptive capacity. Exposure was assessed using historical weather data from 1983 to 2023, sourced from Kerala Agricultural University and NASA POWER site. Key exposure indicators included high-temperature events (greater than 3.5°C above normal), prolonged dry spells (≥9 consecutive days with rainfall <2.5 mm during the southwest monsoon), and heavy rainfall e vents (>64.5 mm/day). Sensitivity was measured using the percentage of flood-prone and landslide-prone areas, population density, along with land-use change trends such as changes in barren and current fallow lands. Adaptive capacity was determined using socio-economic and environmental indicators, including per capita income, GDP, literacy rates, and Normalized Difference Vegetation Index (NDVI) trends.

The findings indicate significant spatial variability in climate vulnerability across Kerala. Thrissur and Palakkad exhibited the highest exposure to extreme weather events, while Alappuzha and Ernakulam had the lowest exposure. At the same time, Alappuzha, Ernakulam and Thrissur were the most sensitive districts due to extensive flood-prone areas and land-use changes. Adaptive capacity was higher in Pathanamthitta and Wayanad, supported by higher literacy rates and stable NDVI trends, while Ernakulam exhibited the weakest adaptive capacity due to lower socio- economic indicators. The overall vulnerability assessment highlighted Thrissur as the most vulnerable district to climate change, combining high exposure, high sensitivity and moderate adaptive capacity. In contrast, Kasaragod was the least vulnerable district. This study highlights the urgent need for district-specific adaptation strategies. Policymakers should enhance adaptive capacity in vulnerable districts through disaster preparedness, ecosystem conservation, and sustainable development. Strengthening infrastructure, promoting sustainable land-use practices, and investing in climate education can help mitigate risks and build long-term climate resilience.

Keywords: Climate Change, Climate Vulnerability, Exposure, Sensitivity, Adaptive Capacity.

Rona Maria Sunil
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STJ-Modulated TEJ Variability: A New Perspective on Intraseasonal Monsoon Dynamics

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ABSTRACT

The Subtropical Jet Stream (STJ) and Tropical Easterly Jet (TEJ) are critical upper-tropospheric features shaping the Indian Summer Monsoon (ISM). This study investigates the positional dynamics of these jets and their relationship with rainfall variability over the Indian region during 2000–2023. Using ERA5 reanalysis data and daily rainfall records from the India Meteorological Department (IMD), we analyzed the zonal and meridional wind fields at 200 hPa alongside rainfall observations. Four distinct jet stream cases were examined: both hemispheric (1) STJ moving equatorward, (2) STJ moving poleward, (3) STJ shifting northward, and (4) STJs shifting southward.

A Tropical Easterly Jet Index (TEJI) was developed by area-averaging the TEJ core at 200 hPa, demonstrating strong correlations with rainfall intensity. Results reveal that equatorward shifts of the STJ weaken the TEJ, reducing rainfall over central India. Conversely, poleward migration of the STJ strengthens the TEJ, driving its northward extension and intensifying monsoonal rainfall, including extreme rainfall events. Northward shifts of both hemispheric STJ enhance TEJ strength, while southward shifts suppress it, altering the spatial distribution of rainfall. These findings underscore the complex interplay between STJ and TEJ dynamics and their role in modulating ISM rainfall. Understanding these mechanisms provides essential insights into atmospheric circulation patterns and their influence on monsoonal extremes, aiding improved prediction and climate resilience strategies in the region.

Keywords: Monsoon, Subtropical Jets, TEJ, Rainfall

Comprehensive Monitoring and Analysis of Aerosol Optical Properties in the Calicut Region Using Advanced Optical Instruments

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ABSTRACT

This study explores the aerosol optical properties, such as Aerosol Optical Depth (AOD), Single Scattering Albedo (SSA), and other significant aerosol characteristics in the Calicut region using state-of-the-art optical instruments. A variety of advanced measurement techniques are utilized, including scattering measurements with a novel broad-spectrum nephelometer (400-700 nm), absorption spectroscopy with an Aethalometer, size distribution analysis via Mini LAS, and speciation of the particles collected in the high-volume air sampler using various analysis methods. Furthermore, the HYSPLIT model is applied to determine the source apportionment of aerosols, offering insights into the sources and transport pathways of atmospheric particles. A high-resolution comparison with MODIS data is also performed to validate and enhance the findings. This integrated approach aims to deepen our understanding of aerosol properties and their effects on air quality and climate in the Calicut region. The results of this research will provide valuable data for regional environmental monitoring and support informed decision-making for air pollution control and climate change mitigation strategies.

Keywords: Aerosol Optical Properties, Broad-Spectrum Nephelometer, HYSPLIT Model, Air Quality Monitoring.

Salma Jose
CARE - 0085

Investigation of Atmospheric NO, NO_2, Ozone, and Nitrate Radical Fluctuations in Calicut Using Cavity-Enhanced Measurements

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ABSTRACT

The study investigates the concentrations of nitrogen oxides (NO, NO_2), ozone (O_3), and the nitrate radical (NO_3) in the urban atmosphere of Calicut city, Kerala, using Incoherent Broadband Cavity- Enhanced Absorption Spectrometers. Measurements are conducted across three distinct wavelength regions: 350-380 nm, 400-550 nm, and 650-680 nm.

Understanding the concentrations of NO, NO_2, O_3, and NO_3 in the atmosphere is crucial for assessing atmospheric chemistry and air pollution. These compounds are involved in key chemical reactions that influence air quality, particularly the formation of ozone (O_3), a harmful pollutant at ground level. NO and NO_2 (Nox) play central roles in ozone formation and degradation, and their interaction with O_3 can lead to secondary pollutants like particulate matter (PM2.5), which poses serious health risks. The nitrate radical (NO_3), a nocturnal oxidant, contributes to pollutant formation, especially at night when its concentration peaks. Overall, the study of NO, NO_2, O_3, and NO_3 is essential for improving air quality management, protecting public health, and addressing the environmental effects of air pollution. These findings contribute to a better understanding of nocturnal atmospheric chemistry and its implications for air quality, especially in urban environments where air pollution is a growing concern.

Keywords: Incoherent Broadband Cavity-Enhanced Absorption Spectrometers, Atmospheric Pollution, Nitrogen Oxides, Ozone, Nitrate Radical.

Sarath Kumar D.
CARE - 0168

Urban Sprawl Assessment Using AI Based ML Techniques - A Case Study on Coimbatore City, Tamilnadu

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ABSTRACT

The urban sprawl is the process of a city that evolves from a high density centre to form a low density area towards its periphery based on its own phases involving the historical outbreak of a city. This study will present urban expansion changes and future spatial expansion of the Coimbatore City Municipal Corporation (CMCC), which comprises of 5 zones (North, South, Central, East and West) and 100 wards. The CMCC boundary is spread across an area of 260.8 sq. km and is undergoing a phase of rapid population expansion, which causes increasing concrete space and decreasing green space. Research regarding LULC's spatiotemporal changing patterns, the simulation and the projection of future scenarios offers a complete view of present and future development possibilities. The study has used Random Forest Classifier in Google Earth Engine for classification and IDRISI selva and Jupyter notebook to simulate the spatiotemporal change transition potential and future LULC simulation, we utilized multi-temporal remotely sensed data from 2000 to 2024 with a 10-year interval.

Independent variables and an integrated Multi Layer Perceptron based CA Markov chain methodology within the Land Change Modeler plugin of IDRISI Selva were utilized. Before the simulation, accuracy of the prediction model has been validated by simulating the year 2020 by comparing that to the supervised 2020 classification map, it show 85% of kappa correctness and 0.83 kappa value. The findings reveal that physical and socioeconomic driving variables have a substantial effect on the patterns of the terrain. The study area had a significant rise in Urban area 35.1% from 2000 expands 43.1% in 2010, 49.3% in 2020, 56.8% in 2024, and 61.1% in 2030. The results are expected to aid society and several organizations such as city planners and policymakers.

Keywords: Urban Sprawl, Google Earth Engine, Land Change Modeler, CA Markov Chain.

Exchange Between Atmospheric Boundary Layer and Free Troposphere over the Indian Monsoon Region

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ABSTRACT

The atmospheric boundary layer (ABL) and free troposphere (FT) exchange are pivotal in addressing the pollution dispersion issue under the growing population and industrialization. Radiosonde and ERA5 datasets over Delhi, Nagpur, Mumbai, and Kolkata in the southwest (SW) and over Gadanki and Chennai in the northeast (NE) monsoon regions are utilized to comprehend the ABL and FT exchange during different seasons of 2016. The diurnal patterns of the ABL and FT exchange flux are characterized by the maximum entrainment at ~11:00- 2:00 IST and detrainment at ~17:00-18:00 IST over different stations. The total ABL and FT flux is dominated by the entrainment due to subsidence over Delhi and Mumbai and horizontal advection over Gadanki while detrainment is due to subsidence and horizontal advection over Chennai during the winter season.

The detrainment due to the horizontal advection and convection dominates over the SW monsoon stations while detrainment due to horizontal advection dominates over NE monsoon stations during the summer monsoon season. The spatial distributions of the ABL and FT exchange flux during the winter and pre-monsoon seasons are dominated by the detrainment over the Deccan Plateau and entrainment over the Indo-Gangetic Plain (IGP) closely related to the Indian topography. While during the summer monsoon and post-monsoon seasons, entrainment dominates over the southern peninsular India and detrainment over central India and over the eastern and western coasts of India which closely resembles the spatial pattern of the climatological mean rainfall. The stronger advective and convective detrainments cause an intense increase in the water vapor transport during the monsoon season. The subsidence over IGP during the winter season leads to an increase in ozone transport causing the increased pollution level.

Keywords: Atmospheric Boundary Layer, Exchange Flux, Topography, Monsoon.

Sharon Williams
CARE - 0071

Boundary Layer and Cloud Characteristics Observed by Ceilometer at a Tropical Station During the 2024 South-West Monsoon

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ABSTRACT

The characteristics of the boundary layer and clouds play a critical role in atmospheric dynamics. This study examines boundary layer and cloud properties measured during the 2024 southwest monsoon period using a ceilometer Lidar installed at CSIR-NIO, Dona Paula, Goa, as part of the Indian Lidar Network Programme (ILNP), coordinated by the Physical Research Laboratory (PRL). During the monsoon season, modest discrepancies were observed between the ceilometer-derived parameters (boundary layer height, cloud base height) and reanalysis datasets.

The maximum boundary layer height (BLH) was recorded in July and September, while the minimum occurred in June. Cloud base height (CBH) was found to be lower in July and higher in June. Both BLH and CBH showed distinct diurnal variations throughout the monsoon months. Temperature, relative humidity, and evaporative fraction were identified as dominant factors influencing BLH during the night, in contrast to the daytime. Additionally, significant differences in BLH and CBH were observed between strong and weak precipitation days in the study region.

Keywords: Boundary Layer Height, Cloud Base Height, Ceilometer.

Application of High-Resolution Climate Simulations to Understand the Impact of Urban Heat Mitigation Strategies in Montreal

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ABSTRACT

Numerous recent studies have suggested the use of cool or white roofs to mitigate Urban Heat Island (UHI) effect. However, these studies are generally based on offline urban model simulations that do not capture the land-atmosphere dynamics and interaction. This study adopts an integrated modelling approach using the Global Environmental Multiscale (GEM) model, where the urban region is represented by a single layer urban canopy model, Town Energy Balance (TEB) scheme. Two model simulations are performed, one without white roofs (GEM_CTL) and one with white roofs (GEM_WR), where the white roofs are represented by higher albedo values. The objective is to assess the net benefits of this mitigation strategy over the island of Montreal, the second-largest urban agglomeration in Canada. A key focus is the role of non-synoptic winds, which may counteract the expected benefits of white roofs.

High-resolution (250m) simulations for summer (2019 & 2020) provide insight into localized wind dynamics and their interactions with urban and topographic characteristics. Analysis suggests that the reduced land-water temperature gradient and associated weakening of sea breeze in GEM_WR lead to a reduction in latent heat flux, partially offsetting the cooling over Montreal Island. Additionally, the planetary boundary layer becomes shallower, and thermal updrafts could be weaker due to the decrease in sensible heat flux caused by the increase in surface reflectivity. As a result, GEM_WR shows a decrease in summer mean precipitation over Montreal, mainly because of the suppression of convective activity brought on by less surface heating and weakened sea breeze. Despite the weakening of sea breeze and associated reduced evaporation, GEM_WR still exhibits cooling over the island. These findings highlight the need for integrated modelling in quantifying the net benefits/impacts of adaptation strategies.

Keywords: Urban Heat Mitigation, White-Roofs, Land-Sea Breeze.

Sreekumar Haridas
CARE - 0015

Looming Drought on India's West Coast: Insights From CMIP6 Projections

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ABSTRACT

The climatological analysis of future temperature and precipitation patterns over the west coast of India (WCI) and the sea surface temperature (SST) over the Arabian Sea adjacent to WCI based on CMIP6 projections is conducted for the near future period 2024-2050. The study used downscaled, bias-corrected, multi-model ensemble mean of diverse climate variables from Global Climate Models (GCMs) available in the CMIP6 under multiple shared socio-economic pathway (SSP) scenarios (SSP2-4.5, SSP3-7.0, and SSP5-8.5) for 2024–2050. This study provides a comprehensive analysis of the intensity and duration of near-future droughts over the WCI, with a special focus on Kerala. The analysis utilizes the self-calibrating Palmer Drought Severity Index (scPDSI), considering the region's projected precipitation and potential evapotranspiration (PET).

Under all SSP scenarios, particularly SSP3-7.0, the WCI is expected to experience increasing temperatures and increases in the frequency of extreme weather events between 2024 and 2050. In the near future, by 2050, the WCI, particularly Kerala, is projected to witness significant (at 99% confidence level) temperature increases of more than 2°C under all SSPs, with SSP3-7.0 having high prominence, indicating extreme weather events towards the middle of this century. The Arabian Sea SST near WCI is expected to rise by ~1.4 °C towards 2050. Significant inter-SSP scenario variations are expected in precipitation and drought patterns over WCI. While central Kerala is projected to experience a significant increase of 225 mm in mean monsoon rainfall under SSP3-7.0, with substantial post- monsoon increases of up to 250 mm (at 90% confidence level), pre-monsoon rainfall in northern Kerala may rise by an insignificant amount of 5–25 mm and south-central Kerala may witness a 5– 10 mm decrease. The projected scPDSI revealed that severe and extreme droughts will increase, with regions like Idukki and Palakkad districts facing prolonged extreme droughts lasting over 90 months, under SSP2-4.5 and SSP5-8.5. Kerala is likely to have more droughts in the near future, which emphasizes the necessity of exhaustive plans to mitigate the wide-ranging effects. The scPDSI analysis highlights the importance of timely water management, particularly in the high-altitude districts of Kerala.

Keywords: Climate Projections, CMIP6, SSP, Droughts, scPDSI.

Sreelakshmi K. S.
CARE - 0093

Exploring the Madden-Julian Oscillation's Influence on Kerala's Rainfall Dynamics

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ABSTRACT

The Madden-Julian Oscillation (MJO) is a dominant mode of intra-seasonal variability influencing global and regional weather systems, including the Indian monsoon. This study investigates the relationship between MJO phases and monsoon onset timing in Kerala from 1983 to 2023 and analyzes seasonal rainfall patterns across five key agricultural stations- Vellanikkara, Vellayani, Ambalavayal, Pilicode, and Kumarakom. Using MJO phase data (RMM1, RMM2, and amplitude) and daily rainfall records, MJO active days (amplitude >1) were identified and categorized into wet phases (2, 3, 4, 5) and dry phases (6, 7, 8). A comprehensive analysis was conducted to examine variations in monsoon onset timing and seasonal rainfall amounts during these phases.

The findings reveal that late monsoon onset is predominantly associated with MJO Phases 2 and 3, whereas early onset is more frequent during Phases 1, 6 and 7. Normal onset was found to be rare, suggesting a strong deviation from climatological averages. Additionally, seasonal rainfall analysis indicates that wet MJO phases contribute to increased rainfall, while dry phases exhibit suppressed precipitation trends. The influence of MJO is particularly significant during the monsoon season, affecting both total rainfall accumulation and its temporal distribution. Understanding these MJO-induced rainfall variations can enhance early warning systems for extreme weather events, including floods and droughts. By integrating MJO-based forecasting into agricultural planning, farmers can make informed decisions regarding crop selection, irrigation scheduling, and disaster preparedness. This study also highlights the importance of incorporating MJO signals into disaster risk management frameworks to improve monsoon predictability and strengthen climate resilience in Kerala. Furthermore, the study emphasizes the need for long-term monitoring of MJO variability and its evolving impact on the monsoon, particularly in the context of climate change. Future research should focus on quantifying the statistical significance of these relationships and exploring predictive models that integrate MJO dynamics with other large-scale climate drivers. By improving monsoon onset and seasonal rainfall predictions, this research can provide valuable insights for policymakers, meteorologists, and agricultural stakeholders in mitigating climate-related risks.

Keywords: Madden-Julian Oscillation, Indian Monsoon, Monsoon Onset, Seasonal Rainfall, Early Warning System, Disaster Risk Management, Climate Resilience.

Intra-seasonal Rain Isotopic Dynamics of Bay of Bengal Region

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ABSTRACT

Understanding the isotopic variability of rain over the Bay of Bengal (BoB) is crucial for interpreting paleoclimate proxies from northeastern India, southeastern China, and the Andaman Islands. The study analyzes 10 years (2012-2021) of rain isotope data from the Andaman Islands to identify key moisture processes using ambient meteorological parameters. We analysed cloud activity, rain, and moisture flux patterns during isotopically enriched and depleted events of the Indian Summer Monsoon (ISM) and Northeast Monsoon (NEM), focusing on the region's diverse moisture sources and seasonal dynamics.

Compared to enriched events, depleted ISM events show intense cloud activity and high rain over central BoB and upstream regions, with low vertically integrated moisture flux (VIMF). The vertical moisture flux profile also shows low values from the surface to 500 hPa, while mid-tropospheric moisture convergence (900–500 hPa) is significantly higher. These patterns suggest four drivers of isotopic depletion: i) High rain fraction (rain/moisture flux, Rayleigh theory), ii) Increased moisture recycling due to large-scale convection and rain over BoB, iii) Rainout history over southwestern India, transporting depleted vapor, and iv) Moisture convergence in the mid-troposphere. Conversely, enriched ISM rain events have high VIMF, minimal cloud activity, and low rainfall, leading to low rain fraction and enriched isotopes. Lower moisture recycling also maintains isotopically enriched rain. During NEM, depleted events show extensive cloud cover and rain over central BoB, with cyclonic VIMF patterns and contributions from isotopically depleted western Pacific moisture. Vertical profiles indicate high moisture flux and consistently strong convergence at all levels. Thus, moisture recycling and Pacific intrusion drive isotopic depletion. Enriched NEM events, in contrast, have lower rain and cloud activity over BoB, with reduced VIMF mainly from the equatorial Indian Ocean, carrying isotopically enriched surface-evaporated vapor. This study highlights the role of moisture flux magnitude, direction, history, moisture convergence, and rain-to-moisture flux ratio in shaping BoB rain isotopic variability, offering critical insights for interpreting paleoclimate records.

Keywords: Stable Isotope, Rain, Paleo-climate, Indian Monsoon, Moisture Flux.

Sreevidya Ravi
CARE - 0091

Analysis of the Extreme Rainfall Event over Kerala on October 16, 2021, Using Numerical Simulation: A Case Study

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ABSTRACT

Extreme rainfall on October 16, 2021, triggered landslides, resulting in significant loss of life and extensive infrastructure damage in the Kottayam and Idukki districts of Kerala. The region received over 80 mm of rainfall per 30 minutes for a duration of one and a half hours. This event was associated with a low-pressure system that developed over the eastern Arabian Sea and followed an unusual southeastward path, leading to intense downpours across Kerala. Observations indicated that the eastern Arabian Sea remained relatively warmer than the western Arabian Sea from early October. Additionally, the weakening of easterly winds during this period led to a gradual reduction in vertical wind shear. Strong warming over the eastern Indian Ocean, the equatorial Indian Ocean, and the Maritime Continent was also evident, likely enhancing the lower-level westerly flow. Moreover, mid-level relative humidity (600 hPa) remained consistently high over the Kerala coast from the beginning of October.

During the event, a higher amount of cloud liquid water content was observed in the lower levels of the atmosphere, while ice water content was absent. Numerical simulations of the event were conducted using the Advanced Research Weather Research and Forecasting (WRF-ARW) model. Six simulations were performed to assess the model sensitivity in predicting the extreme rainfall event, employing three cloud microphysics parameterization schemes and two cumulus parameterization schemes. The model results were compared with Doppler Weather Radar (DWR) observations, IMERG rainfall data, and ERA-5 reanalysis data. The WSM6-KF scheme successfully predicted the extreme rainfall event six hours in advance, though with some over-estimation. The simulation showed cloud water content extending up to 400 hPa just before the event, whereas observations indicated its presence only in the lower levels (700 hPa). Additionally, the simulation predicted ice water content in the upper levels during the event, which was absent in observations. This variation may explain the overestimation of rainfall in the WSM6-KF simulation.

Keywords: Extreme Rainfall, Low-Pressure Area, WRF Simulation, DWR.

Sripathi Gollapalli
CARE - 0029

Variability of the South Asian High and its Impact on Indian Summer Monsoon Rainfall: A Multi-Scale Analysis

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ABSTRACT

This study investigates the relationship between the South Asian High (SAH) and Indian Summer Monsoon Rainfall (ISMR) across different spatial and temporal scales using observations and seasonal models. The analysis considers past-climate (1940–1980) and current-climate (1981–2020) periods to assess changes in SAH-ISMR interactions. Key findings indicate that the northwest- southeast (INW-SE), north-south (INS), and intensity (IINT) indices of SAH exhibit strong positive correlations with ISMR (~0.67, ~0.60, and 0.51, respectively), while the east-west (IEW) index shows a negative correlation (-0.52). These relationships are generally stronger in the past-climate than in the current-climate, except for the IINT index, which remains significant.

Regionally, the INW-SE and INS indices are closely linked to all-India rainfall, particularly over northwest India (NWI) and central India (CI), while the IINT index strongly influences rainfall over south peninsular India (SPI). In the current climate, increased rainfall over NWI and SPI aligns with positive INS and IINT indices, respectively. However, northeast India (NEI) rainfall shows no significant relationship with SAH indices, except for the IEW Index, Ih Is linked to Increased NEI rainfall during El Niño years. Additionally, SAH indices show a significant positive (negative) relationship with meridional (zonal) wind shear, influencing monsoon dynamics by modulating moisture anomalies. The ISMR–SAH relationship is further evaluated using four seasonal forecast models (CANCM4, NEMO, CANSIP, and CFSv2) for the 1982–2016 period, with most models successfully capturing these associations, albeit with some variations in correlation strength. The study also highlights the influence of sea surface temperature (SST) anomalies on monsoon variability. INW-SE years are associated with La Niña conditions and enhanced positive vorticity over the monsoon region, leading to increased ISMR. Conversely, IEW years exhibit significant negative rainfall anomalies, linked to El Niño patterns and negative vorticity anomalies. These findings underscore the critical role of SAH in modulating ISMR variability and emphasize its importance in improving seasonal monsoon predictions.

Keywords: South Asian High, East-West Index, Northwest-Southeast Index, Seasonal Rainfall, Indian Summer Monsoon, Tele-connections, Homogeneous Regions, Zonal and Meridional Shear.

Sriyansu Nayak
CARE - 0092

Spatio-temporal Analysis of Land Use Land Cover Changes on Urban Heat Island Intensification and Thermal Comfort in Palakkad, Kerala

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ABSTRACT

Rapid urbanization and alterations in land use/land cover (LULC) have led to unsustainable growth and the rise of urban heat islands (UHI) in Indian cities. Palakkad, a city in Kerala, is characterized by higher temperatures compared to other parts of the state. This study examines the effects of urbanization and LULC changes on the Land Surface Temperature (LST) dynamics in Palakkad from 2014 to 2024. Using Landsat 8 imagery, LST, Normalized Difference Vegetation Index (NDVI), and Normalized Difference Built-up Index (NDBI) for the region is derived. The analysis revealed a positive correlation between LST and NDBI, a negative correlation between LST and NDVI, and a negative correlation between NDVI and NDBI. Notably, the Alathur taluk exhibited a significant temperature increase between 2014 and 2024, while Mannarkad experienced a comparatively smaller temperature increase over the period. To further investigate LULC changes, Sentinel-2 data from 2017 to 2023 was used to map land use and land cover changes across each taluk of Palakkad.

The findings indicated that the build up ares increased in all taluks, but Alathur taluk experienced a 5.61% rise in built-up areas and an 8.28% reduction in tree cover, whereas Mannarkad showed a 4.42% rise in built-up areas and a 3.13% decrease in tree cover. Additionally, calculation of Discomfort Index (DI) using meteorological data for March to May in 2014 and 2024 has been done. The Kriging Gaussian interpolation method was employed to create DI maps, highlighting higher discomfort levels in Alathur taluk. The results indicate a growing discomfort index in Palakkad from 2014 to 2024, underscoring the influence of urbanization and LULC changes on thermal comfort and urban heat island effects. This micro-level study offers crucial insights into smart city development, policy formulation, planning, and heat island mitigation within Palakkad's urban boundaries. The substantial rise in urban settlements and decline in green spaces in the Alathur area require immediate action plans, aligning with India's Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs), to safeguard the well-being of residents.

Keywords: Spatio-temporal, Urban Heat Island, Land Surface Temperature (LST), Discomfort Index (DI).

Socio-Economic Vulnerability and Climate Resilience in Coastal Kerala: A Multi-criteria Assessment

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ABSTRACT

Coastal communities face increasing vulnerability to climate-related hazards, necessitating localized assessments for resilience-building. This study presents a Socio-Economic Vulnerability Index (SEVI), an integrative framework combining socio-economic and environmental indicators to evaluate vulnerability in Kerala's coastal fishing communities. Data from 290 households across nine fishing villages were collected using systematic random sampling. The Analytic Hierarchy Process (AHP) was applied to assign weighted scores to vulnerability factors, and bootstrapping validated the robustness of results.

Findings reveal significant spatial disparities in vulnerability, with Vizhinjam identified as the most vulnerable due to high dependency ratios, inadequate infrastructure, and limited adaptive capacity, while Arthunkal and Chellanam exhibited greater resilience. Key vulnerability drivers include livelihood instability, lack of access to essential services, and environmental degradation, particularly in aquatic ecosystems. In addition to vulnerability assessments, SEVI aligns with Sustainable Development Goals (SDGs) 1, 8, 13, and 14, providing a comprehensive and scalable tool for assessing and monitoring climate vulnerability in data-scarce coastal regions. The study highlights the urgent need for tailored policy interventions, including improved coastal infrastructure, diversified livelihood options, enhanced educational opportunities, particularly for women and increased climate awareness. SEVI offers an evidence-based framework for guiding sustainable development and climate adaptation strategies, ensuring that interventions are directly aligned with the specific vulnerability profiles of each community. The approach has broad applicability beyond Kerala, supporting localized climate adaptation efforts in other vulnerable coastal regions worldwide.

Keywords: Socio-Economic Vulnerability Index (SEVI), Coastal Resilience, Climate Adaptation, Sustainable Development Goals (SDG), Policy Interventions.

Assessing Heat Stress Trends in Kerala: A Regional Analysis Using Heat Index

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ABSTRACT

Understanding spatial and temporal variations in heat intensity through quantitative metrics like the Heat Index can provide valuable insights for climate planning, ensuring resilience against escalating heat-related risks. Kerala has been experiencing a steady rise in temperatures, exacerbated by high humidity levels, leading to increased heat stress across the state. The combined effects of climate change, urbanization, and land-use changes have intensified the frequency and severity of extreme heat events, particularly in urban and inland regions. This study assesses heat stress trends in Kerala by calculating the Heat Index (HI) using temperat"re a'd relative humidity data from the India Meteorological Department (IMD) of period from 1980 to 2023. The analysis covers seven stations, including Thiruvananthapuram, Alappuzha, Kannur, Punalur, Kottayam, Palakkad, and Kozhikode, capturing variations across different geographic and climatic conditions. The Mann-Kendall (MK) test, Sen's slope (SS) estimator, and linear trend were applied to quantify the trend in annual average heat index (AAHI), annual heat stress days (HSD), and heat index for each month.

The results indicate a noticeable increasing trend in heat stress across Kozhikode, Kannur, and Palakkad over the period from 1980 to 2023. Heat Stress Days (HSD) increased by approximately 40% in Kozhikode, 1.5 times in Kannur, and nearly threefold in Palakkad. Additionally, the Average Apparent Heat Index (AAHI) rose by 5% in Kozhikode, 10% in Kannur, and 3% in Palakkad. The heat index value during the monsoon months (June to September) has shown an increasing trend over the years in Alappuzha and Thiruvananthapuram. Kottayam exhibited a 19% decrease in AAHI. These findings highlight the spatial heterogeneity of heat stress trends across Kerala, emphasizing the need for localized adaptation strategies. The findings from this study provide valuable insights into heat stress trends and regional vulnerabilities in Kerala, supporting the development of targeted adaptation strategies for public health and climate resilience.

Keywords: Heat Index, Heat Stress, Mann-Kendall Test, Climate Variability, Kerala.

Site Specific Slope Stability Analysis Using Limit Equilibrium Method (LEM) for Selected Landslide Susceptible Soil Slope Faces of Malappauram District of Kerala, India

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ABSTRACT

This study evaluates the stability of seven soil slope (SS) surfaces in the north-western part of Malappuram district, Kerala, using the Ordinary method (OM) and Morgenstern-Price (MP) approaches of the Limit Equilibrium Method (LEM). These slope faces were located in high and very high landslide-susceptible zones, as identified in previous studies. The primary objective is to assess slope stability under varying water saturation conditions—dry, 25%, 50%, 75%, and 100%. The Factor of Safety (FOS) was computed for each slope surface under these conditions.

Results indicate that all slopes remain stable in dry and low saturated conditions but exhibit a significant reduction in stability with increasing water saturation. A consistent decline in FOS with rising moisture levels highlights the reduction in shear strength of slope's soil. Among the analyzed slopes, SS-5 was identified as the most unstable, with FOS dropping below 1 at minimal saturation, while SS-2 was the most stable, showing minimal FOS variation across saturation levels. Comparatively, the Morgenstern-Price method yielded lower FOS values, suggesting higher accuracy in slope stability assessment. Given that these slopes exhibit critical instability under saturated conditions - analogous to monsoon scenarios - this study underscores the necessity of slope treatment measures to enhance stability, particularly during heavy rainfall seasons, to mitigate potential landslides.

Keywords: Slope stability, Limit Equilibrium, Morgenstern-Price, Ordinary Method, Landslide Susceptibility, Factor of Safety (FOS)

Tesna Maria
CARE - 0042

Moisture Transport and Its Link With Extreme Monsoon Rainfall Over the West Coast of India

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ABSTRACT

The Arabian Sea and the Bay of Bengal have experienced significant changes in the monsoon- related convective processes recently, which may affect precipitation variability over the Indian subcontinent. Recent studies suggest that extreme rainfall over the west coast region may be expected to persist with future warming scenarios. This study investigates the link between moisture transport and extreme rainfall over the west coast using observational and reanalysis datasets for the monsoon seasons (June to September) from 1990 to 2023. The profiles of wind and humidity from the ERA5 reanalysis, daily rainfall data from the India Meteorological Department (IMD), and NOAA sea surface temperature (SST) for the period 1990-2023 were used. The vertically integrated moisture flux has been decomposed into its dynamic and thermodynamic components to study the moisture flux over the Indian west coast.

Over the past 34 years, except for the north-west part of the west coast region, it is apparent that the dynamic component of moisture transport has remained relatively constant. Conversely, the thermodynamic flux component shows a statistically significant increase, confined to the south-west region which correlates with the sea surface temperature(SST) increase in the Arabian Sea and might have contributed to the increasing trend of extreme rainfall over the region.

Keywords: Moisture Transport, Monsoon Extremes, West Coast, SST, Arabian Sea Warming.

ENSO Modulation of Absorbing Aerosol Dynamics over the Indo-Gangetic Plain Under a Changing Climate

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ABSTRACT

This study examines the influence of the El Nino Southern Oscillation (ENSO) on the transport, deposition, and distribution of aerosol concentration over the Indo-Gangetic Plain (IGP) from 2006 to 2024, a span of around 18 years. The analysis shows that the influence of El Nino and La Nina has decreased in determining the distribution and its movement. Previous studies until 2010 have shown that the ENSO causes an increase in aerosol concentration during El Nino and a decrease during La Nina. As a result, measured levels of Aerosol Optical Depth (AOD) ought to indicate a rise during El Nino and a decrease during La Nina.

However, the observation shows that the aerosol concentration is not affected by El Nino or La Nina. The AOD obtained shows high values even during the La Nina phase and lower levels during El Nino, indicating that there are other factors that depend on the concentration of aerosol in IGP. Strong winds across the Arabian Peninsula have been observed throughout multiple La Nina years, including 2008,2020,2021 and 2022. These winds aided in the long-range aerosol movement towards the IGP. This is accomplished by contrasting the meridional zonal wind trajectory with the backward wind trajectory. As a result, aerosol concentrations above the IGP rose even during the La Nina episode. The wind is stronger in the Arabian Peninsula during the 2015–2016, 2023-2024 El Nino, but it becomes weaker as it approaches India. The amount of aerosol decreased as a result of less long-range transport to the IGP.

Keywords: El Nino Southern Oscillation, Aerosol Optical Depth, Indo-Gangetic Plain.

Climate Change and Rising Underwater Noise Level in the Indian Ocean: Implications on Acoustic Communication and Sensing

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ABSTRACT

Climate change is fundamentally altering the acoustic environment of the Indian Ocean, leading to significant challenges for underwater communication, navigation, and marine life. Rising ocean temperatures, glacier melt, acidification, and shifting wind patterns are not only affecting marine ecosystems but also modifying the way sound propagates underwater. These environmental changes, combined with increasing human activities such as shipping, deep-sea mining, and offshore infrastructure development, have contributed to elevated underwater noise levels, reducing the signal-to-noise ratio (SNR) of underwater acoustic systems. Understanding and predicting these changes will be vital for maintaining effective and superior performance of underwater acoustic communication, navigation, and military systems operating in the Indian Ocean.

Advanced signal processing techniques, improved modelling of sound propagation under evolving ocean conditions, and sustainable ocean management practices are considered in addressing these challenges. Several studies have reported the continuous noise measurements in Indian Ocean region revels that ocean sound floor has increased over past decade mostly due to anthropogenic activities. This paper presents a case study on how the variation in sound speed affect SNR in underwater acoustics with the help of sound propagation model, comparing the past and present scenario. In this study, the transmission loss estimated using underwater acoustic model is used to compute the received level and there by analysed the SNR for two scenarios. It is observed that for the past scenario with low NL can have higher SNR whereas In the present scenario due to the increase in NL, the SNR is found be less which reduces the performance of acoustic systems in sea.

Keywords: Signal to Noise Ratio, Ambient Noise Level, Climate Change, Sound Speed.

Venkadesh Samykannu
CARE - 0089

Spatio-temporal Assessment of Ecological Variability in Punjab Using Remote Sensing Ecological Index and Paddy Yield Analysis

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ABSTRACT

Agricultural landscape of Punjab is undergoing significant ecological transformations due to climatic variability and anthropogenic pressures. Understanding these changes is essential for sustainable land management and agro-advisory services. This study assesses the spatio-temporal ecological status of Punjab during the Kharif season from 2001 to 2023 using the Remote Sensing Ecological Index (RSEI). The research integrates key environmental indicators—Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST), Normalized Difference Built-up and Soil Index (NDBSI), and Wetness-derived from MODIS satellite data. These indicators were normalized, standardized, and analyzed using Principal Component Analysis (PCA) to construct RSEI, which quantifies ecological variability and its implications for land productivity.

The results reveal substantial changes in Punjab ecological conditions over the study period. Rainfall trends from 1981 to 2023 is emphasize the region of climatic variability, with July recording the highest precipitation (298.5 mm) and December the lowest (12.4 mm). The annual rainfall fluctuated between 268.72 mm and 956.81 mm, significantly influencing ecological conditions and agricultural output. The study also explores the relationship between RSEI and paddy yield, underscoring the critical role of ecological health in agricultural sustainability. The proportion of land classified under "poor" ecological status peaked at 3.28% in 2005 before declining to 2.33% in 2023, whereas the "fair" category increased from 28.93% in 2001 to 30.58% in 2023. The "moderate" class exhibited notable fluctuations, covering 42.87% in 2001 and stabilizing at 44.86% in 2023. Conversely, the "good" category declined from 19.11% to 14.4%, indicating a contraction of high-quality ecological zones. The mean RSEI values ranged from 0.563 in 2001 to 0.629 in 2005, followed by a decline to 0.593 in 2020, before recovering to 0.621 in 2023, highlighting the dynamic interplay between environmental and anthropogenic factors. The findings provide continuous ecological monitoring and adaptive land management are imperative for enhancing sustainability.

Keywords: Remote Sensing Ecological Index, Punjab, Climate Variability, Agro-Advisory, Sustainable Agriculture.

Geo-Spatial Analysis of Erosion and Deposition Trends in the Chaliyar River Basin, Kerala (2014–2024) Using Remote Sensing and GIS-Based Spectral Indices

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ABSTRACT

Rivers are dynamic systems that constantly evolve due to both natural processes and human activities. Over the past decade, the Chaliyar River Basin in Kerala, India, has undergone significant geomorphological changes driven by erosion and sediment deposition. This study leverages remote sensing techniques combined with key spectral indices - such as the Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), Soil-Adjusted Vegetation Index (SAVI), Water Ratio Index (WRI), and Automated Water Extraction Index (AWEI) - to analyze changes in sediment distribution between 2014 and 2024. Multi- temporal satellite data from Landsat 8 (2014) and Landsat 9 (2024) serve as the foundation of this research. Data from the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) were utilized to detect morphological shifts in the river over time. The analysis reveals that the basin experienced approximately 4.06 km² of erosion and 17.91 km² of sediment deposition, leading to a net sediment gain of 13.85 km² over the study period. Areas most affected by erosion were riverbanks and high-energy sections, where monsoonal flooding, deforestation, sand mining, and human interventions has significantly influenced sediment transport. The annual erosion rate was found to be 0.406 km² per year. In contrast, sediment deposition resulted in the formation of sandbars, mid-channel islands, and expanded floodplains, altering the river's natural hydraulic flow. The average annual deposition rate stood at 1.791 km² per year, primarily due to a reduction in water flow velocity, sediment influx from upstream sources, and artificial modifications such as embankments that altered sedimentation patterns. The study indicates that the river is currently experiencing a depositional phase, with sediment accumulation outpacing erosion. This shift raises concerns about increasing flood risks, as the rising riverbed and changing flow patterns could impact hydrological stability. These findings emphasize the importance of strategic sediment management to control excessive siltation, reduce flooding risks, and maintain navigability. Remote sensing proves to be an efficient and cost-effective tool for monitoring large-scale riverine changes, offering crucial insights into sediment transport and landform evolution. To sustain the long-term ecological and hydrological health of the Chaliyar River Basin, proactive measures such as erosion control initiatives, sediment dredging, and riparian buffer restoration are necessary. The study provides valuable information for policymakers, hydrologists, and environmental planners, aiding in the development of sustainable strategies that balance erosion mitigation, land use, and water resource management.

Keywords: Erosion, Deposition, Remote Sensing, Spectral Indices, Sediment Transport.

Integrating Remote Sensing and Statistical Modelling for Water Quality Assessment Using Sentinel-2: A Case Study of Sasthamkotta Lake, Kerala

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ABSTRACT

This study explores the application of Sentinel-2 satellite imagery in conjunction with Multiple Linear Regression (MLR) models to evaluate water quality in Sasthamkotta Lake, a significant freshwater body and Ramsar site in Kerala. With increasing pollution due to urbanization and agricultural runoff, efficient and cost-effective monitoring methods are essential. While traditional field-based techniques provide accurate data, they are often expensive and limited in spatial scope. To address these limitations, this study utilizes spectral indices, including the Normalized Difference Chlorophyll Index (NDCI) and Normalized Difference Water Index (NDWI), to estimate key water quality parameters such as Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Electrical Conductivity (EC), and pH.

The model's predictions were validated using field data from the Kerala State Pollution Control Board (KSPCB), with EC showing the strongest correlation ($R^2 = 0.77$), followed by DO ($R^2 = 0.61$), pH ($R^2 = 0.543$), and BOD ($R^2 = 0.515$). These results demonstrate the feasibility of using satellite-based approaches to monitor water quality efficiently. Sasthamkotta Lake's ecological health is influenced by its geological and hydrological characteristics, with lateritic soil and metamorphic rock formations affecting groundwater infiltration and pollutant retention. Seasonal monsoon variations further impact water quality by influencing runoff and sediment deposition patterns. The study findings highlight the utility of remote sensing in capturing spatial water quality variations, with NDWI and MNDWI effectively identifying turbidity and suspended solids, while NDCI served as an indicator of eutrophication. Elevated NDCI values corresponded with declining DO levels, pointing to increased algal activity and potential ecological stress on the lake. These insights emphasize the potential of remote sensing in tracking pollution trends and supporting conservation efforts. This study underscores the value of satellite-based remote sensing as a scalable and cost-effective approach for monitoring freshwater ecosystems. By bridging traditional field-based assessments with advanced geospatial techniques, it provides a robust framework for tracking water quality trends and informing policy decisions. The methodology can be extended to other water bodies, supporting sustainable water resource management in the face of increasing environmental pressures.

Keywords: Water Quality, Remote Sensing, Spectral Indices, Sentinel-2, Regression Model.

Vishnu Subran
CARE - 0073

Landslide Susceptibility Assessment Using Frequency Ratio Method in Sub-Watersheds of Meenachil River Basin

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ABSTRACT

Landslide is a form of mass wasting in which debris, rock, and soil are moved down a slope by gravity. The vulnerability of an area to landslides is determined by elements such as slope angle, geological structure, soil type, land cover, and proximity to faults and hydrology. Understanding these factors is crucial for effective landslide hazard assessment, mitigation, and land-use planning. Landslides in the Western Ghats pose a severe hazard to human lives, infrastructure, and the environment. The region's susceptibility is exacerbated by its distinctive geological features, which include steep slopes, deeply weathered rock formations, and heavy rainfall. The study aims to assess the landslide susceptibility in the Poonjar-Tikovil sub-watersheds of the Meenachil River basin in the Western Ghats of Kerala using the Frequency Ratio (FR) method and Geographic Information System (GIS) techniques.

Paleo-landslide points were identified and used for creating a landslide inventory, and used as training dataset for susceptibility mapping, while additional landslide locations extracted from Google Earth Imagery were used for validation. Twelve landslide conditioning factors were considered: elevation, slope, aspect, curvature, stream density, lineament density, geomorphology, land use/land cover, lithology, topographic wetness index, stream power index, and distance to roads. The frequency ratio analysis revealed that 36.41 sq. km (17.77%) and 66.11 sq. km (32.26%) of the 204.02 sq. km study area fall into very high and high landslide susceptibility zones, respectively. The findings highlight the significance of geomorphological and hydrological factors in landslide occurrences and provide valuable insights for disaster risk management and land-use planning in the region.

Keywords: Landslide Susceptibility, Frequency Ratio, GIS, Meenachil, Hazard Mapping.

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